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# SCHOOL SCIENCE AND MATHEMATICS

MAY 1954

# School Science and Mathematics

*A Journal for All Science and Mathematics Teachers*

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*In May, when sea-winds pierced our solitudes,*
*I found the fresh Rhodora in the woods,*
*Spreading its leafless blooms in a damp nook,*
*To please the desert and the sluggish brook.*
*The purple petals, fallen in the pool,*
*Made the black water with their beauty gay;*
*Here might the redbird come his plumes to cool,*
*And court the flower that cheapens his array.*
*Rhodore! if the sages ask thee why*
*This charm is wasted on the earth and sky,*
*Tell them dear, that if eyes were made for seeing,*
*Then Beauty is its own excuse for being:*
*Why thou wert there, O rival of the rose!*
*I never thought to ask, I never knew:*
*But, in my simple ignorance, suppose*
*The self-same Power that brought me there brought you.*

—"The Rhodora"
RALPH WALDO EMERSON

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# School Science and Mathematics

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# SCHOOL SCIENCE AND MATHEMATICS

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## GEORGE G. MALLINSON, ASSISTANT EDITOR

SCHOOL SCIENCE AND MATHEMATICS has now taken another step forward in its journalistic career. At a recent meeting of the Board of Directors an outstanding man in the field of Science Education was selected to assist the editor in making further improvement in the *Journal's* mission to teachers. This man, Prof. George G. Mallinson, is already well known throughout much of the world in the field of education in science and mathematics. He is a young man of great ability and energy, a faculty member of one of the great Michigan colleges, who began his career as a teacher at Whitesboro, New York, in 1938 after obtaining the A. B. at the State College for Teachers at Albany. Three years later he received the M.A. degree at the same school, then became head of the science department at the Eden Central School in his native state. In 1947 he received the Ph.D. from the University of Michigan and entered the college field as a teacher at Iowa State Teachers College, Cedar Falls, in the fall of the same year. The following year he transferred to the Western Michigan College of Education at Kalamazoo as Assistant Professor of Psychology and Education. Here he has risen rapidly and now holds the rank of a full professor and is acting director of the graduate division. From 1942 to 1944 he was with Uncle Sam as a Sergeant in the Classification Section at Camp Upton, New York. He has spent some time in travel in our nearest neighbors, Canada and Mexico.

Dr. Mallinson has an active role in both his state science groups and in the larger organizations of the nation. He is the representative of the National Association for Research in Science Teaching for the Cooperative Committee on the Teaching of Science and Mathematics, a member of the American Educational Research Association, the Central Association of Science and Mathematics Teachers, the National Association of Biology Teachers, National Education As-

sociation, and others. His list of publications forms an extensive array for so short a period of active teaching. These include major articles in *Science Education*, *The Science Teacher*, *Journal of Educational Research*, *The Geography Teacher*, *The American Biology Teacher*, and a number of other important journals, but many of his most important articles have been published in SCHOOL SCIENCE AND MATHEMATICS. He is co-author with Prof. Francis D. Curtis of the University of Michigan of an excellent textbook, *Science in Daily Life* and a *Teachers Manual and Key* for the same, published by Ginn & Co.

Dr. Mallinson celebrates his birthday and the birthday of his country on the same date. Troy, N. Y. is his birthplace, on July 4, 1917.

Now, when Dr. Mallinson calls on you, he is the special representative of your most important school journal, SCHOOL SCIENCE AND MATHEMATICS.

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## ERRATA

In our March issue (1954) some errors were noted in the tables of data given on pages 178 and 179. The corrected tables are given below.

TABLE I. DEFICITS IN PERCENTAGES OF DOCTORS, NURSES, AND ATTENDANTS IN ILLINOIS MENTAL HOSPITALS

| | *Doctors* | *Nurses* | *Attendants* |
|---|---|---|---|
| 1949 | 47 | 91 | 57 |
| 1951 | 47 | 90 | 59 |
| 1952 | 39 | 89 | 58 |

TABLE II. RADIO OF DOCTORS, NURSES, AND ATTENDANTS TO PATIENTS IN ILLINOIS MENTAL HOSPITALS

| | *Doctors* | *Nurses* | *Attendants* |
|---|---|---|---|
| 1949 | 1 to 189 | 1 to 163 | 1 to 12 |
| 1951 | 1 to 177 | 1 to 153 | 1 to 12 |
| 1952 | 1 to 152 | 1 to 144 | 1 to 12 |

TABLE III. HOURS PER PATIENT PER YEAR FOR DOCTORS, NURSES, AND ATTENDANTS

| | *Doctors* | *Nurses* | *Attendants* |
|---|---|---|---|
| 1949 | 11.00 | 12.75 | 173.33 |
| 1951 | 11.75 | 13.72 | 173.33 |
| 1952 | 13.68 | 14.75 | 173.33 |

# OPPORTUNITIES FOR SCIENCE TEACHING IN THE ELEMENTARY GRADES*

DORIS YOUNG
*Northwestern University, Evanston, Ill.*

In recent years educators have repeated the phrase "every teacher a teacher of reading." We would agree that all must be concerned with the improvement of reading skills. Today I would urge this group of elementary science teachers to encourage *each classroom teacher to be a science teacher*. We must encourage teachers to recognize and utilize the many opportunities for teaching science.

A study conducted by students in a science methods course at Northwestern University indicates the challenge this group must accept. In a four week period each student recorded possible science teaching situations in the classroom in which she was student teaching. Also, the observer recorded the way in which the situation with a "science potential" was utilized. Problem solving in areas outside of natural or physical science was not included.

In this brief period a wide range of topics was noted. At the primary level more situations were identified. There appeared to be more opportunities for discussion of the environment, and children's interests were considered more frequently in the primary grades. Records from the upper elementary grades indicated fewer instances of science teaching situations. According to these records, a higher percentage of possible science teaching situations was developed by teachers in the primary grades than in grades four to six. This survey indicated many opportunities for teaching science were lost.

An incidental science program is not being advocated. Teachers and curriculum directors prefer to avoid the connotation of "incidental." However, a program is *not* incidental if the teacher is alert for opportunities to teach science. It is *not* haphazard if teachers have clearly in mind the goals of science teaching. The problem solving approach applied in guiding children's activities brings far reaching opportunities for science teaching.

The reasons for neglect of these opportunities have been noted in the literature. Teachers lack confidence; many have an inadequate background; critic teachers frequently do not offer science experiences. Too frequently, pre-service observation provides a student only experience with a book-reading type of science program.

The present teachers of elementary science must lead others to recognize these opportunities and encourage their utilization. Class-

* Presented at the Elementary School Group of the Central Association of Science and Mathematics Teachers, Nov. 28, 1953, at Chicago, Illinois.

room teachers who are especially interested in science must accept a leadership role. The science teacher is a busy person, yet he may be able to help classroom teachers in his building in the following ways:

1. He can share materials by displaying them on the faculty bulletin board. Announcements of local exhibits and science news items may be presented.
2. The science teacher can encourage the development of a community resource file. Information about places of interest and local resource persons may be made available for others.
3. Building workshops may be suggested by the science teacher. If three or four teachers can work together trying out experiments with his help, those teachers will feel more ready to guide children in similar activities.
4. Demonstrations by children stimulate interest. A science fair in the building, planned with children in one or two rooms, will be of value.
5. Frequently older children can help younger groups. A sixth grade boy can explain his electro-magnetic toy and buzzers to another group, for example. The boy who has a good insect collection may show it to a first grade. We need to recognize the resources in children.
6. The science teacher may give leadership in building a school museum.
7. With children in his class the science teacher may build a simple equipment box which can be moved from room to room.
8. Working with the school librarian the science teacher can encourage interesting displays of science books and materials.

Present science teachers may also help teachers in training. There is constant need for descriptions of classroom activities. Brief accounts including "how it started" and "what was done" would help future teachers.

If the science teacher is near a training institution he can utilize the service of students for field trips, and encourage work with small groups.

As the science teacher works he can give subtle encouragement to the classroom teachers. Let the classroom teacher know she doesn't have to know all the answers to children's questions. Sometimes the science teacher appears to be a "superman" of encyclopedic information. Other teachers then feel inadequate. As the science teacher talks with colleagues he needs to use the "why not try it out" approach. His enthusiasm may inspire the teacher to try new techniques.

Informally the science teacher may suggest science experiences related to the on-going activities in a classroom. Transportation, for example, could lead to many science activities.

Occasionally it seems that some science teachers rather jealously guard their subject matter. If the fourth grade studies weather, the sixth grade teacher may be disturbed because it is his "speciality." Science teachers need to begin where children are, develop further interests, build deeper understandings.

The science teacher might encourage teachers to engage in a cooperative study. What problems arise? What do children bring from their environment to initiate science activities? Do interests "peak" at certain age levels?

It will take much time and effort on the part of the science teacher to know teachers in his building, to build rapport, to give help with materials. But the science teachers must accept the challenge of these wasted opportunities for science teaching. Together we must promote the problem solving approach and encourage teachers to recognize and utilize the many opportunities for teaching science.

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## NATIONAL ASSOCIATION OF BIOLOGY TEACHERS TO CONTINUE CONSERVATION PROJECT

The NABT Conservation Committee decided at their recent annual work conference in Boston to extend their committee beyond the 3-year period covered by the $10,000 grant-in-aid by the American Nature Association which expires this June.

The Conservation Committee will soon complete the compilation and editing of over 150 projects from thirty states submitted by state committees. The "Handbook for Teaching Conservation and Resource-use" containing these descriptions will be published by the Interstate Press at Danville, Illinois this year.

The Conservation Committee has also reprinted an eight page "Symposium on Training the Conservation Worker" which resulted from a cooperative project with The American Institute of Biological Sciences.

The Bibliography of "Free and Inexpensive Materials in Conservation Education" by Muriel Beuschlein is being revised contemplating a second printing this year.

The Symposium reprint and the Bibliographies are available for 10¢ each from the Project Leader, Dr. Richard L. Weaver, P.O. Box 2073, Ann Arbor, Michigan.

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## FEDERAL FUNDS FOR EDUCATION

Additional Federal funds totalling $11,545,924 have been reserved by the Office of Education, U. S. Department of Health, Education, and Welfare, for school construction projects in "federally-affected" defense areas, S. M. Brownell, Commissioner of Education, announced today.

The funds will be used to help 39 local school districts in 20 States provide the necessary classroom accommodations for their increased enrollment because of nearby Federal installations. The States scheduled to receive the funds are: California, Colorado, Georgia, Illinois, Indiana, Kansas, Louisiana, Maryland, Michigan, Montana, New Jersey, New Mexico, New York, Nevada, Ohio, South Dakota, Tennessee, Texas, Virginia, and Washington.

These additional funds bring to more than 26 million the total amount reserved to date under provisions of Title III of P.L. 246, authorized by the 83rd Congress.

## A Page From
## CARNEGIE INSTITUTE OF TECHNOLOGY

*John Christian Warner*

THE combination of a country-school-teacher mother and a love of science moved Dr. J. C. Warner from the family farm near Goshen, Indiana, to the fields of education and science. In some twenty-five years, he has given good teaching and books to education; he has added knowledge to science; and, during World War II, he contributed valuable scientific and administrative service to America.

Now, after rising from Instructor of Chemistry through the academic ranks to Professor and Head of the Department and Dean of Graduate Studies in the College of Engineering and Science, he will give his friendly strength and his full experience in education and administration to the office of President of Carnegie Institute of Technology.

# TO TEACHERS OF SCIENCE AND MATHEMATICS IN THE SCHOOLS

J. C. WARNER
*Carnegie Institute of Technology, Pittsburgh 13, Pa.*

The following remarks are directed to the teachers of science and mathematics in the secondary schools in the hope that they will find helpful the views of one who has been a teacher of science and engineering students in college for a quarter of a century. During many of these years as the teacher in charge of the General Chemistry course at Carnegie Institute of Technology, I had direct contact with students in their first year in college. Most of these students came from the upper fourth or fifth of their secondary school classes, yet the great majority had not arrived at college with either the necessary preparation or proper motivation for going ahead with science and mathematics.

I was greatly perplexed by the situation and gave much study to the problem. Among other things I took an active interest in an association of the high school science teachers in Western Pennsylvania. I found many good teachers in the organization—men who knew their subject, had creative ideas about teaching, knew what the student should be prepared to do, and had the ability to properly motivate those students qualified to look forward to a career in science or engineering. When these teachers were free they were sending us well prepared students who made remarkably good records in college and subsequently in their careers.

But many good teachers are not free—they are hampered and restricted by their school administrations both as to methodology and as to objectives. In many of our secondary schools we are told that preparation for colleges and professional school cannot be a major objective because the majority of the graduates do not go on to college. Instead "preparation for life" must be the objective, with the consequence that we too often have "fuzzy" courses in general science and the wonders of science instead of a disciplined introduction to the laws of nature, theories to explain natural phenomena, and the methods of science. We too often have commercial arithmetic and bookkeeping instead of basic algebra, trigonometry, and geometry.

[Some years ago, just after G. W. Warner had finished his first four years at Indiana University and had been assigned to the Goshen (Indiana) high school to teach physics and chemistry, he found, as one of his pupils, J. C. known by his classmates as "Jake." The young teacher soon discovered that Jake was not just another pupil. Two years later J. C. completed his high school course and went on to Indiana University. There he again made a name as a topnotcher and, while a graduate student, as a most efficient laboratory assistant. Further work at Indiana and later at the University of Michigan gave him the necessary training for his future work as a great teacher, research man, and administrator. Carnegie, we congratulate you. This article was written at the special request of the editor.—G.W.W.]

We survey almost everything in a superficial manner without ever getting down to business about real mental discipline and root knowledge.

It is my belief that secondary education in the sciences and mathematics which is best for college preparation may also be best as preparation for life. What would be better preparation for life than gaining a real understanding of the methods of science—methods which are the most efficient ever discovered by man for the objective solution of his problems? What would be better preparation for life than gaining a real understanding of the most basic laws of nature and an ability to apply these laws to the solution of new problems which confront the individual? And I believe that proper secondary education in the sciences will influence an individual to be more objective in his approach to the public problems which he encounters as a citizen.

All of my experience leads me to venture the following recommendations to teachers of science in the secondary schools:

1. Approach the teaching of science with the clear intention of giving the student a thorough understanding of the methods of science. Show how generalizations or laws of nature are discovered by planned observations and experiments. Emphasize the limitations on generalizations. Show how by inductive reasoning theories are evolved to explain behavior according to natural laws. Show how by deductive reasoning undiscovered generalizations may be predicted from theories and how these predictions may then be tested by observation and experiment.

2. Always be willing to sacrifice extent of coverage of subject matter for thoroughness in understanding the most basic laws and theories.

3. Forget about the "marvels of science"—the complex devices, gadgets, synthetic fibers, medicinals, etc.—which have resulted from the applications of science but cannot really be understood until the student is much farther along with his studies in college or professional school. Give the student a real understanding of the behavior of simple electrical circuits rather than a superficial description of the complicated systems involved in television, radar, guided missiles, and proximity fuses. Give him an understanding of basic theories of atomic and molecular structure, and the relation between structure and properties for elements and simple molecules, instead of pretending that a high school student can really understand vitamins, hormones, synthetic fibers, the antibiotics, synthetic and natural plastics, and the silicones.

4. In addition to giving a thorough understanding of the simple basic laws and theories of science, give prime attention to developing

a competence in students to apply these in the solution of problems which are new to them, connecting these new situations, in so far as possible, to the experience of the students.

I believe this type of science teaching can be made as exciting for secondary-school students as that which emphasizes the marvels of applied science, and it will be vastly superior as preparation for college or professional school, and, I believe, as preparation for life also.

Concerning the teaching of mathematics in the schools, I would advocate a greater emphasis on the meaning of mathematics—its symbolism, its logic, its great capacity for the economical and precise statement of problems, and its effectiveness as a universal language. The great Willard Gibbs, ordinarily very retiring, modest, and reticent, is said to have spoken only once in meetings of the Yale University faculty. During a strenuous debate over the relative merits of languages and mathematics in the Yale curriculum, Professor Gibbs rose to remark, "Gentlemen, mathematics *is* a language." But how may students ever think of mathematics as a means of communication?

I am of the opinion that training in mathematics consists too frequently of memorizing rules, theorems, and methods for the manipulation of certain types of equations and expressions. As a consequence, the student's ability is limited pretty much to solving the same kind of problems he has solved before. I have noticed a widespread inability to state a real problem in mathematical terms. For example, most of the thousands of students I have taught in the General Chemistry course over the years were very adept at solving simultaneous equations if the equations were given to them in the usual form with $x$, $y$, $z$ as variables and $a$, $b$, $c$ as constants. But they were thrown into confusion when $P$, $V$, and $T$ became variables, and considered a teacher totally unreasonable to expect them, given the usual results of an analysis of a mixture of gases, to set up the necessary simultaneous equations and solve them to obtain the composition of the gas mixture.

A student learns by what he does and experiences, and only by what he does and experiences. Hence good teaching in science and mathematics, as in all other fields, must be focused on what the student becomes competent to do "under his own steam." We should agree on objectives, but we should not pretend that there is a single best methodology for attaining our objectives. Different teachers have different personalities and characteristics and hence will best accomplish a desired objective by different methods. I am convinced that what may be the best method for one teacher may be a poor method for another.

To do the best job of preparing secondary-school students for col-

lege, and I believe for life, we must be willing to sacrifice extent of of coverage of subject matter, so that we can help the student become more competent in more important things:

1. A thorough understanding of the basic laws, principles, theories, and philosophy of science and mathematics.
2. An ability to state precisely and accurately the real problems with which he is confronted, and the ability to make this statement in mathematical terms when appropriate.
3. The ability to apply basic laws, principles, and theories to obtain solutions to problems which involve new situations.
4. The ability to judge the reasonableness of his solution.
5. The ability to learn from each experience.

Motivation toward a career in science or engineering which arises from teaching directed toward these objectives is effective and lasting, but motivation having its origin in the interest aroused by superficial, descriptive accounts of the marvels of applied science is neither sound nor lasting, leading all too frequently to disappointment and failure in college or professional school.

I would like to say a word about the fine art of communication in oral and written English—an art so important to all citizens in a democracy and an art necessary in all the professions. Full responsibility for developing competence in this field cannot be placed on English teachers in either school or college. Teachers in all fields should share this responsibility, and I hope the secondary-school teachers of science and mathematics will assume their share.

All of us are engaged in an enterprise of tremendous importance—the selection, motivation, and training of young men and women who are to become professional scientists and engineers in a free democratic society. We have a great responsibility and a great opportunity. From my own experience, I know that you who are teachers of science and mathematics in the schools occupy a key position in the proper motivation of young people toward careers in science and engineering. Furthermore you can have a great influence in determining attitudes, habits of study, and the setting of proper goals. No one is doing a more important job for America than the good teacher in our schools.

Finally, I hope I may be permitted to acknowledge publicly my indebtedness to and my affection for a great teacher of students and other teachers—Glen W. Warner. He had a great and good influence on my life and my career.

---

Do you own a copy of FIFTY YEARS OF TEACHING SCIENCE AND MATHEMATICS? If not, write Ray C. Soliday for one.

# SELECTING A TEXTBOOK IN MATHEMATICS

J. S. GEORGES
*Wright Junior College, Chicago 34, Ill.*

The pedagogical principles employed in the organization and presentation of the instructional materials of a textbook embody its educational features. The distinguishing features of a textbook should be grouped under five main classes: (1) aims of instruction; (2) organization of materials; (3) methods of instruction; (4) psychological principles; (5) evaluation of instruction.

## AIMS OF INSTRUCTION

Efficient teaching is purposeful teaching. Purposeful teaching is teaching in terms of definite aims or objectives. Every educational feature of a system—the plant, the teacher, the facilities, and the textbooks—is but a means to an end. The end is the attainment of the educational aims.

If a textbook is to cooperate in the attainment of the educational aims, the particular educational aims of the course which the textbook represents must be clearly defined and definitely stated. This sound pedagogical principle is not often carried out in the plan of a textbook. The authors, in most cases, assume that the teacher is able to determine what the aims of instruction in each unit, or chapter, should be from the materials of instruction therein presented.

The learning products of mathematics are of three types: (1) understandings; (2) abilities; and (3) appreciations. Understanding involves the rationalization of a concept or process. Ability involves the acquisition of the necessary skills for the manipulation of a process. Appreciation involves the appraisal of the significant values of a concept or process.

The understandings in any mathematics textbook are of two types: the rationalization of the previously learned processes and concepts; and the rationalization of the new processes and concepts. The textbook should utilize familiar relationships to rationalize new mathematical processes and concepts. In turn it should use these same processes and concepts to give meaning to useful relationships. This dual role of rationalization is a feature that should be looked for in selecting a text.

For a further acquisition of manipulative skills in the four fundamental operations with whole numbers and fractions, exercises should be introduced in the form of recall drills. These exercises should be presented where the particular operation has a definite use.

When new geometric abilities, such as the measurement of lines and

angles and construction of geometric figures, are developed, wherever possible they should be associated with the old arithmetic abilities in order to motivate their learning. They should also be used in the study of new relationships.

The development of appreciation of mathematics as a method of thinking and its importance in life and the world should be a definite educational objective in a mathematics textbook. For the attainment of this objective, four distinct methods are usually used: (1) motivating unit-stories; (2) historical accounts; (3) exercises with social and economic significance; (4) illustrations depicting the applications of mathematics.

Each unit of the textbook can and should be presented by means of an interesting and challenging account of the significance of the theme of the unit. The pupil is thus made to realize the importance of the processes and concepts of the unit and is given definite reasons why he should study the unit.

The historical accounts in a textbook present the romantic side of mathematics. They tend to inspire the young mind to a real appreciation of mathematics. If we wish to create within him an appreciation of the power of our number system and its importance in our lives, let him read the interesting account of "Finger Computation." If he is to see the beauty of form through mathematics, let him ponder over "The Search for Beauty of Form."

The exercises presented in a mathematics textbook should be based upon common experiences. Through them the pupil becomes aware that mathematics provides a means of solving problems which he encounters in everyday life.

Children like to look at pictures. The pictures in a textbook in mathematics should be good pictures, pictures with a purpose and meaning, which are intended to show the child the applications of mathematics and thus create in his mind an appreciation of the subject.

## Organization of Materials

In organizing the materials of instruction, the pedagogical principles used are to facilitate learning and enhance the value of instruction. The organization of a mathematics textbook is usually based upon the following procedures: (1) unitary organization; (2) psychological arrangement; (3) correlation of the branches of mathematics.

The method of organization known as the "Unit Plan" or "Unitary Organization" selects a fundamental concept or process of mathematics as a unit and relates and fuses together all the materials of the unit into an integrated whole. The plan is based upon the following principles: (1) each unit of instruction furnishes definite learning

products which become the definite aims of instruction to be attained; (2) each unit of instruction is based upon a central theme; (3) the central theme of each unit is a significant part of the course of study; (4) each unit of instruction is composed of definite and distinct unit elements; (5) the instructional materials of each unit are centered about and focused upon the central theme of the unit; (6) each unit of instruction is teachable; (7) each unit of instruction is measurable.

The development of each unit of instruction in a mathematics textbook should be psychological. That is, instead of a formal definition of a process followed by illustrations and applications, the meaning of the process is learned through its applications, as illustrations. The process is unfolded gradually in terms of the experiences of the pupil. He discovers for himself its meaning and properties and states them.

The philosophical idea underlying mathematical instruction is that *mathematics is a method of thinking*. Accordingly, arithmetic, algebra, and geometry, as three branches of mathematics, are closely related, being the aspects and manifestations of the same general truth—mathematical thought. Thus, the ideas and principles of these separate subjects may be correlated and presented together to enrich the meaning and usefulness of mathematical thought.

The correlation of arithmetic and algebra is brought about in two distinct ways. First, the arithmetic operations are used to illustrate the special cases of algebraic principles. In the second place, the correlation of algebra and arithmetic is established by interpreting algebraic processes and concepts as generalizations of arithmetic processes and concepts.

The following examples show how arithmetic operations are used in connection with geometric principles, thus correlating the ideas of these two branches of mathematics. Measurement of lines and angles expresses geometric facts in terms of arithmetic numbers. Magnitude of a geometric figure is a geometric fact; its numerical representation is an arithmetic operation. In the representation of quantities by lines, as in the bar and line graphs, the magnitude of a definite quantity is an arithmetic fact; its representation by a geometric element is a geometric fact. The same thing is true in the representation of quantities by means of angles, as in the circle graph. The use of geometric figures in indirect measurements is an association of geometric and arithmetic principles.

Algebra and geometry are correlated by enabling the pupil to discover geometric facts intuitively and state them in terms of the symbolic language of algebra. Not only are the symbols of algebra

utilized in the statement of geometric facts, but also geometric facts are in turn utilized in clarifying algebraic principles and making them meaningful.

## Methods of Instruction

In a textbook, the authors use certain methods and modes of presentation and development of materials which strive for the attainment of the instructional aims. This should be a distinguishing feature in selecting a textbook. The teaching of a process is accomplished by means of suitable illustrations which the pupil can perform. At each step of learning appropriate questions are asked, the answers to which enable the pupil to see what he is doing and why he does it in that particular way. The various manifestations of each process thus aid in attaining its mastery.

After a process or concept has been learned, the pupil is presented with exercises, arranged in the order of difficulty, in order that he may apply what he has learned to different situations.

The various teaching steps are so designed that the child discovers the necessary facts inductively. Each step may be considered as an experiment devised for a special purpose. The steps together constitute the complete induction.

The main utilization of mathematical thinking is in the discovery, interpretation, and statement of quantitative relationships. Relationships should be emphasized in a mathematics textbook. There are six methods usually presented in mathematics textbooks for the study of quantitative relationships. They are: (1) the method of differences; (2) the method of ratios; (3) the tabular method; (4) the graphic method; (5) the formula; and (6) the method of proportions. Relationships are usually presented: (1) as statements; (2) as rules; (3) as formulas; and (4) as graphs.

The use of the inductive and experimental method of approach provides a number of related special cases which lead the pupil to discover the general principle which embodies all of them. This general principle then is stated formally as a consequence of such discoveries.

The method of analysis which the pupil learns to use in the teaching steps culminates naturally in its systematic use in the solution of problems. The formal work on analysis is presented in the solution of problems. The analysis of a problem consists of the following steps: (1) understanding the relationship; (2) determining what is required; (3) determining what facts are given; (4) deciding what operations to use; and (5) estimating the answer.

The function concept is manifested in quantitative thinking to such an extent that the teaching of functionality in mathematics should

be a primary objective in a mathematics textbook. Because of the various forms in which functionality can be stated and represented and its many different kinds of applications, the function concept can be used as the unifying principle coordinating the materials of the course into the development of mathematical thinking.

The function concept may be interpreted as: (1) dependence between related quantities; (2) variation or change; (3) relationship; and (4) comparison. Functionality is represented by means of (1) tables; (2) graphs; (3) statements; and (4) formulas.

## Psychological Principles

In learning, as in any other activity, children differ with respect to desires, abilities, applications and interests. Hence, it is necessary that in the methods and modes of instruction used by the teacher special provision be made for motivation, for individual differences, and for remedial measures. This the authors of a mathematics textbook should attempt to do.

The child's interest in mathematics can be created, increased, and maintained if mathematics is presented to him as a useful method of thinking and not a "collection of tricks." The text should present mathematics as a method of thinking, in terms of situations that are close to the child. Specifically, motivation is sought through: (1) the unit-story, which tells what the unit is, how it is used, and why the pupil should study it; (2) utilizing pupil's previous knowledge; (3) enabling the pupil to assume responsibility by addressing the teaching to him directly, and enabling him to discover facts by himself; (4) challenging the pupil's ability through supplementary problems; (5) maintaining his interest by presenting the practical aspects of mathematics in such a form that he can actually learn and apply them; and (6) developing in him a sense of appreciation.

Since pupils differ in abilities, interests, and applications, the authors should provide for the varying needs of the pupils in three ways: (1) each set of exercises is carefully graded and listed according to increasing difficulty; (2) most of the sets of exercises are grouped into A, B, and C groups; (3) supplementary problems are provided in all of the units to be utilized by the teacher in motivating the pupil who has ability but does not apply it, and in inspiring the "young mathematician" to do "research."

For the diagnosis of difficulties and inhibitions in the fundamental operations of arithmetic, the recall drills can be used in connection with the work of the unit where these drills are presented. They may also be used as remedial measures in the elimination of such difficulties.

## Evaluation of Instruction

Testing should be an integral part of the teaching program. It should be considered as the taking of an inventory in learning. To be effective, testing should be at frequent intervals and not once or twice during the semester. The procedure to be recommended is the administration of a test at the end of each unit. The text should provide unit tests which are comprehensive in character, based upon the learning products of the unit.

The testing program consists of three parts: (1) the review; (2) the summary; and (3) the test.

A review of the unit covers the essential points considered in the unit. It serves as an indicator of what learning actually has taken place.

After the unit has been taught and learned, the pupil should be given an opportunity to reorganize the ideas which he has learned. Such an organization reveals whether or not he has mastered the unit elements to the extent that he sees their relationships to one another and to the theme of the unit.

The final step in the testing program is the unit test. The tests of understanding in the text should be carefully formulated. They should employ the accepted test forms, such as, the completion form, the matching test, the true and false, and the multiple choice. More than one form should be used in each test. Each test should be designed to be finished in one period.

*Questions* (which the reader may answer)

1. What is meant by the disciplinary values of mathematics? The cultural values? The utilitarian values?
2. What are the so-called "Cardinal Principles" of education? How do they differ from Herbert Spencer's list of the objectives of education?
3. What is the difference between a logical and a psychological arrangement?
4. What is unitary organization? Name the principles of such organization.
5. What is meant by the function concept in mathematics? Explain why it is considered as one of the most important objectives of mathematical instruction.
6. How are educational objectives of a subject determined?
7. What is meant by activity analysis? How is it used in education?
8. Distinguish between understanding and appreciation. Between understanding and ability.
9. What is meant by the spiral plan of organization? The parallel plan?
10. What is the difference between the inductive and the deductive mode of teaching?
11. What is the difference between a concept and a process? Illustrate.
12. What is meant by the rationalization of a process? Of a concept?
13. What is meant by intuitive geometry? How does it differ from demonstrative geometry?
14. What is meant by induction? The inductive method?
15. Distinguish between the analytic and the synthetic method.
16. What is meant by the validity of a test? The reliability?

17. What is an objective test? What are the advantages of such a test? The disadvantages?
18. Distinguish between a diagnostic test and a prognostic test. Illustrate.
19. Discuss the principle of transfer of training as applied to mathematics.
20. Name some educational functions of mathematics which are intrinsic.

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## PROGRAM FOR STUDY OF INSECTS IN THE SCHOOLS

This year marks the hundredth anniversary of professional entomology in the United States. Entomologists in business and government, and teachers in elementary schools, high schools, colleges and universities, hope to use this event as a means of informing the public on how insects affect the economy of this nation and the health and welfare of our people.

No group or individual—rural or urban—escapes loss from attacks of harmful insects. They compete with us for food and fiber; they feed on our livestock and our pets; they spread diseases among us and our animals; they attack much of what we build and many of the things we manufacture.

These are some of the reasons why professional entomologists and educators are campaigning this centennial year for a better public understanding of the insect problem. They have planned a most interesting program for young people. Its aim—and great appeal—is education through participation. Equally as important, it can be adapted to kindergarten or college.

Here are a few ways to introduce the insect story into your classroom:

*Question-and-Answer Period*—Read any book on insects and prepare a few general questions for class discussion. Why are insects hardier and better equipped to survive than human beings? What are the main parts of an insect's body? What life stages do insects pass through in their development? How do they do as much damage as $4 billion a year?

*Insect Collections*—Assign members of your class to the task of collecting different kinds of insects. Each student will find collecting them a lot of fun; he will always remember some of the things he learns.

*Field-Trips*—Arrange for a visit to a home, farm, or factory where a large-scale insect-control operation is taking place. The county agricultural agent or pest-control operator in your community usually can be of help in suggesting places to visit.

*Nature Walks*—Schedule a series of nature walks when the weather is warm enough. Keep track of the different kinds of insects that can be identified and try to determine if they are harmful or beneficial.

*Demonstrations*—Have members of the class present demonstrations on insects. Typical ideas for presentations include "Insects and Homemaking," "Magic Under a Microscope," and "Insects and Our Health."

Lists of books and films on insects have been furnished State Librarians, national and state education associations, State Education Directors, NEA State Directors of Rural Education, and persons in State Departments of Education in charge of audio-visual education. They can probably suggest additional material to help you.

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## SCIENCE STUDENTS IN THE U.S.A. AND THE U.S.S.R.

While the number of graduates from engineering colleges in the U.S.S.R. increased from 28,000 to 33,000, the number in the United States decreased during this period (1950–53) from 53,000 to 25,000. The estimated number of graduates in 1955 for the United States is 23,000, while in the U.S.S.R. the number is 50,000. The number of graduates of technical institutes in the United States in 1952 was approximately 1,100, but for the same year in the U.S.S.R. the number was 60,000. The annual output of scientific personnel in the United States is decreasing, while in the U.S.S.R. it is rapidly increasing.

# EXPERIENCES IN THE STUDY OF AQUATIC LIFE*

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One service of the aquatic biologist today is the evaluation of water quality through a study of the bottom fauna or microscopic plant and animal life of our streams and lakes that have been damaged by pollution.

The well-known smallmouth bass bait, the dobsonfly larva (hellgrammite) lives among the large stones in the swift riffles of our larger, warmer streams for 3 years before crawling to the stream margin to pupate and emerge as a night-flying adult.

"Wigglers," or the nymphs of burrowing mayflies *Hexagenia limbata* and *H. bilineata* burrow from 1 to 3 years in the bottom muds of our large rivers before they emerge for their ephemeral life out of the water.

Recently Curry (1953) has shown that the common "bloodworm" or midgefly *Tendipes plumosus* requires a year to complete its life cycle in Michigan lakes. Other midges such as *Tendipes tentans* may have 3 or 4 broods in a year in fish ponds and elsewhere, according to Sadler (1935).

Animals that live or should be found on the bottom of a stream can be recorders of suitable environmental conditions or catastrophes in any given stream or lake. A knowledge of their presence or absence may be an aid to the sanitary engineer or the chemist who cannot visit a stream daily or hourly to catch a slug of pollution released through some mishap, carelessness, or lack of adequate treatment facilities.

The most productive types of streams are those with boulder-strewn rubble or coarse gravel bottoms. The riffles of these are preferred by organisms of generally large size such as caddisfly larvae, mayfly nymphs, dobsonfly larvae, stonefly nymphs, snails, clams, and crayfish.

Figure 1, illustrates a stream bottom sampler consisting of a brass frame 1 foot square attached to another brass frame to which a net of at least 20 meshes to the inch is attached. The bottom animals within a square foot of stream bed are collected by turning over the stones or washing them off thoroughly in a pail of water close at hand. Mayfly, stonefly, damselfly and dragonfly nymphs, dobsonfly larvae, and

* Presented at the Biology Section of the Central Association of Science and Mathematics Teachers, Nov 27, 1953, at Chicago, Illinois.

snails are dislodged readily and most of them are swept by the current into the net.

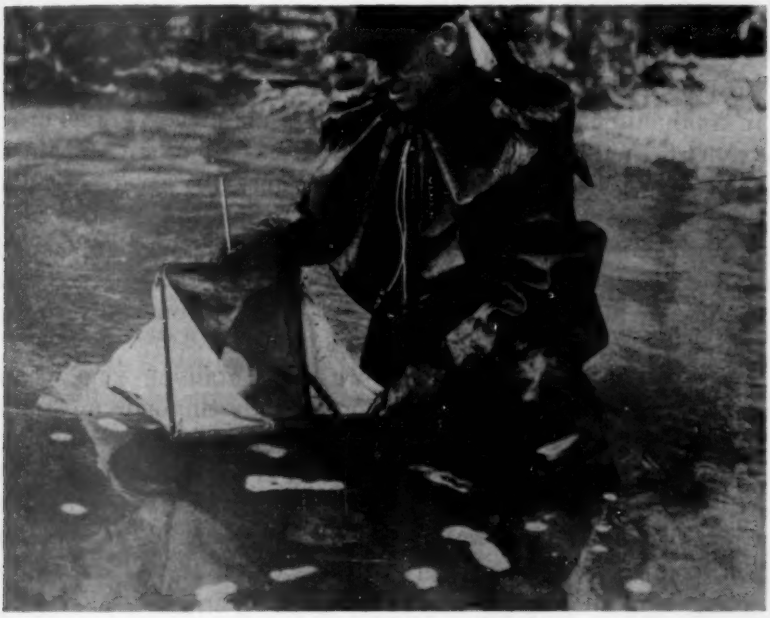

FIG. 1. A stream bottom sampler.

Where the stream is sluggish and possesses mud bottom or sand covered with silt or ooze, two types of samplers are in general use.

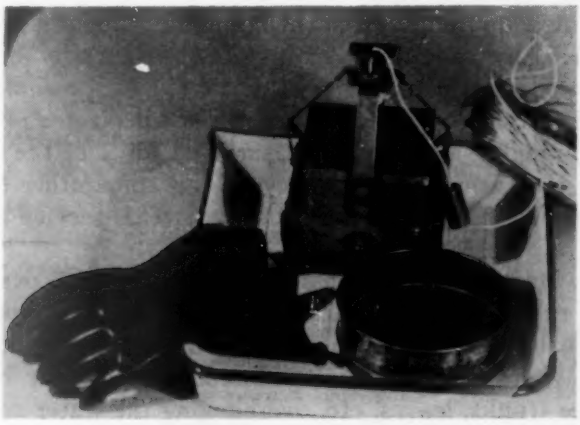

FIG. 2. The Ekman dredge.

The Ekman dredge, Figure 2, is probably most widely used and is ideal for sampling mud bottoms in both streams and lakes.

In streams with a sandy bottom, the Petersen dredge, a much heavier dredge, can be used. Mud or fine sand brought up from the bottom with these samplers is deposited in a tub or large pail, diluted with water, stirred and then poured through a 30-mesh sieve. The catch is preserved in 5–10 per cent formaldehyde and counted in the laboratory.

In conducting a survey of a stream, the sampling of gravel or rubble riffles is preferred because of the great variety of aquatic animals that can live there. In a clean stream, the following groups of aquatic insects are invariably represented—in stream riffles—the family Hydropsychidae (net spinners) of the caddisflies, the Heptageniidae and Baetidae of the mayflies, the Parnidae or riffle beetles, crayfish, mollusks [usually Sphaeriidae (small bivalves) or snails] a variety of midgefly larvae, and a few stonefly nymphs.

Severe pollution by industrial wastes containing zinc, copper, cyanides, etc. or low oxygen conditions quickly eliminate most of the above groups from a stream, but the work of the aquatic biologist in clearly demonstrating effects of pollution is sometimes complicated by the drifting of clean-water animals from undamaged tributary streams into the polluted waters. As an example of this, years ago, the writer stopped with some fishery workers at a riffle of a small stream draining from an Arkansas coal mine. The hydrogen-ion concentration (pH) of the water, which was 4.5, was taken. In spite of the high acidity, there were some filamentous algae growing upon the bottom, and solely out of curiosity, a stream square-foot bottom sampler was placed on the bed of the stream in a riffle close at hand and the stones turned over within the square foot area. To our surprise, the net contained a single dobsonfly larva (hellgrammite) about $\frac{2}{3}$ grown in apparently healthy condition. An inspection of nearby bridge abutments showed a single mass of eggs. There was the possibility that the larva might have dropped from the egg mass deposited on the bridge by a wide-ranging adult and had survived for 2 of the 3 years required by it to complete its life cycle, but some other explanation such as drifting in from a clean tributary stream seemed more plausible.

Warm water smallmouth bass streams with rapids over large flat stones or rubble almost invariably contain dobsonfly larvae (hellgrammites) unless slugs of pollution occur to interrupt their 3-year life cycle. Where the larvae of these insects should occur, bridge abutments, tree trunks, leaves, etc. overhanging the water are inspected for their white egg masses, about the size of a penny, deposited by the female adult during the night.

The soft muds of the slackened waters of the Mississippi River normally support large burrowing mayflies *Hexagenia limbata* or

*H. bilineata* (called "Wigglers" by fishermen). While conducting a pollution survey of the river from Alton, Illinois to Cape Girardeau in early December 1952, at Alton, Illinois where they had been abundant in bottom samples collected there in earlier sampling visits, they were no longer present, but farther down the river at a station below the Wood River Refineries where the muds were oily, they made an appearance where they had occurred infrequently before. It was deduced that receding river levels caused pollution to increase at Alton compelling these animals to leave their burrows in the bottom mud and drift downstream to the Wood River area of large oil refineries where they could not possibly survive long in the presence of oil, phenols and other pollutants.

In 1941, the author's interest in effects of pollution on aquatic life developed from a striking case of destruction brought about in the Shenandoah River by wastes from a large, new viscose (rayon) plant which within a period of a year extinguished virtually all of the bottom animals and game fish that formerly lived in abundance in a section of the river sampled periodically for 2 years with a stream bottom sampler in a fisheries project prior to pollution. The magnitude of the destruction of bottom animals is illustrated by Table 1, which shows the abundance of animals above and below the source of pollution on one collecting trip August 12, 13, 1943. The South Fork of the Shenandoah River and its smaller North Fork join at Riverton to form the main stem of the Shenandoah River (See map, Figure 3). A large viscose (rayon) plant was erected about 1939–1940 near Front Royal, Virginia on the South Fork about one mile above the junction on the South Fork. In 1941, evidence that pollution from this plant was beginning to affect the main stem of the river was manifested by the dying off of clams. Then followed a great fish kill due to an accidental spill of sulphuric acid wastes, but the river did not recover from this. The kill saw the end of good fishing for game fish in the Shenandoah River proper for the next 10 years. It was the biology teacher of Berryville, Virginia High School who in 1942–1943, living in a cottage along the Shenandoah River, urged the writer to take the first series of samples (known to the writer) in which a stream bottom sampler was used to demonstrate pollution. The biology teacher had noted that muskrats had left the river and ducks no longer used it near his place. He knew the 4-mile section of the Shenandoah River in his neighborhood had been sampled during the course of a fisheries project for a considerable period before the erection of the viscose plant.

Table 1 gives the data for one station (near Skyline Caverns) above the source of pollution on the South Fork of the Shenandoah River and for several stations within a 4-mile stretch of the river in

RESULTS OF A BOTTOM FAUNA SURVEY OF THE SHENANDOAH RIVER AFTER POLLUTION, AUGUST 12, 13, 1943. NUMBER OF BOTTOM ANIMALS PER SQUARE FOOT.

| | Pollutional Status | 1 | | 2 | | 3 | 4 | | 5 | | 6 | | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Skyline Caverns above Front Royal, Va. | | Shenandoah River Shepherd's Ford, Berryville, Va. | | First Tributary Creek below Shepherd's Ford | Fish Pot Riffle | | Near Mouth of Spout Run | | Near Mouth of Bill's Branch | | Castleman's Ferry |
| | | A | B | A | B | | A | B | A | B | A | B | |
| Aquatic Earthworms: | | | | | 1 | | | | 2 | | | | |
| Oligchaeta | P | 1 | — | 3 | | 1 | 3 | 5 | | 2 | 3 | 4 | |
| Neuroptera larvae: *Sialis* | C | | | | | | | | | | | 1 | |
| *Corydalus* (Helgrammites) | C | 16 | 7 | | | | | | | | | | |
| *Chauliodes* | C | | | | | | | | | | | 1 | |
| Mayfly Nymphs: | | | | | | | | | | | | | |
| *Stenonema* | C | 60 | 32 | | | | | | | | | | |
| *Isonychia* | C | 23 | 2 | | | | | | | | | | |
| *Potamanthus* | C | | | | | | | | | | | | |
| *Ephemerella* | C | 16 | 1 | | | | | | | | | | |
| *Caenis* | C | | | | | | | | | | | | |
| *Baetis* | C | 57 | 48 | | | | | | | | | | |
| Damselfly nymphs | | 5 | 1 | | | | | | | | | 1 | |
| Dragonfly nymphs | | | | | | | | | | | | | 1 |
| Beetle larvae: | | | | | | | | | | | | | |
| *Stenelmis* larvae | C | 28 | 24 | | | | | | | 1 | | | |
| *Stenelmis* adult beetles | C | 38 | 20 | | | | | | | 1 | 1 | | |
| Caddisfly larvae: | | | | | | | | | | | | | |
| Hydropsychidae larvae | C | 348 | 189 | | | | | | | 1 | | | |
| *Neureclipsis* | C | 7 | 1 | 1 | | | | | 1 | | | | 3 |
| *Philopotamus* | C | 2 | — | | | | | | | | | | |
| Aquatic Moths: | | | | | | | | | | | | | |
| *Elophila* | C | 3 | 3 | | | | | | | | | | |

| | Pollutional Status | 1 | | 2 | | 3 | 4 | | 5 | | 6 | | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Skyline Caverns above Front Royal, Va. | | Shenandoah River Shepherd's Ford, Berryville, Va. | | First Tributary Creek Shepherd's | Fish Pot Riffle | | Near Mouth of Spout Run | | Near Mouth of Bill's Branch | | Castleman's Ferry |
| | | A | B | A | B | Ford | A | B | A | B | A | B | |
| Midgeflies, blackflies, etc.: | | | | | | | | | | 1 | | | |
| Tendipedidae larvae | C | 4 | | | | | 2 | | | | | 3 | |
| *Simulium* | F | 102 | 51 | | | | | | | | | | |
| *Ptychoptera* pupae | C | | | | | | | | | 1 | | | |
| Snails and clams: | | | | | | | | | | | | | |
| *Nitocris* | C | 56 | 49 | | | | | | | | | | |
| *Alasmidonta* | C | | | | | | | | | | | | |
| *Sphaerium* | P | 64 | 15 | | | | | | | | | | |
| *Physa* | F | | | | | | | | | | | | |
| *Ferrissia* | F | 1 | | | | | | | | | | | |
| Total number of animals | | 791 | 443 | 4 | 1 | 1 | 5 | 5 | 3 | 7 | 4 | 10 | 4 |
| Total wet weight of animals in grams | | 19.055 | 12.919 | 0.031 | 0.145 | 0.003 | 0.075 | 0.039 | 0.096 | 0.016 | 0.024 | 0.207 | 0.173 |
| Average number of bottom animals per station | | 617 | | 2.5 | | 0.5 | 5.0 | | 4.5 | | 7.5 | | 2.0 |
| | | Above Pollution | | Below Pollution in Berryville, Virginia, Section | | | | | | | | | |

F = Facultative. C = Clean Water. P = Pollution Tolerant.

the Berryville section on the main stem of the Shenandoah River immediately above Castleman's Ferry, 30 miles below the source of pollution. In the latter section, earlier biological studies had illustrated that the abundance of bottom animals in the main stem of the Shenandoah had been comparable with that of the South Fork above Front Royal and the North Fork of the Shenandoah near Strasburg, Virginia.

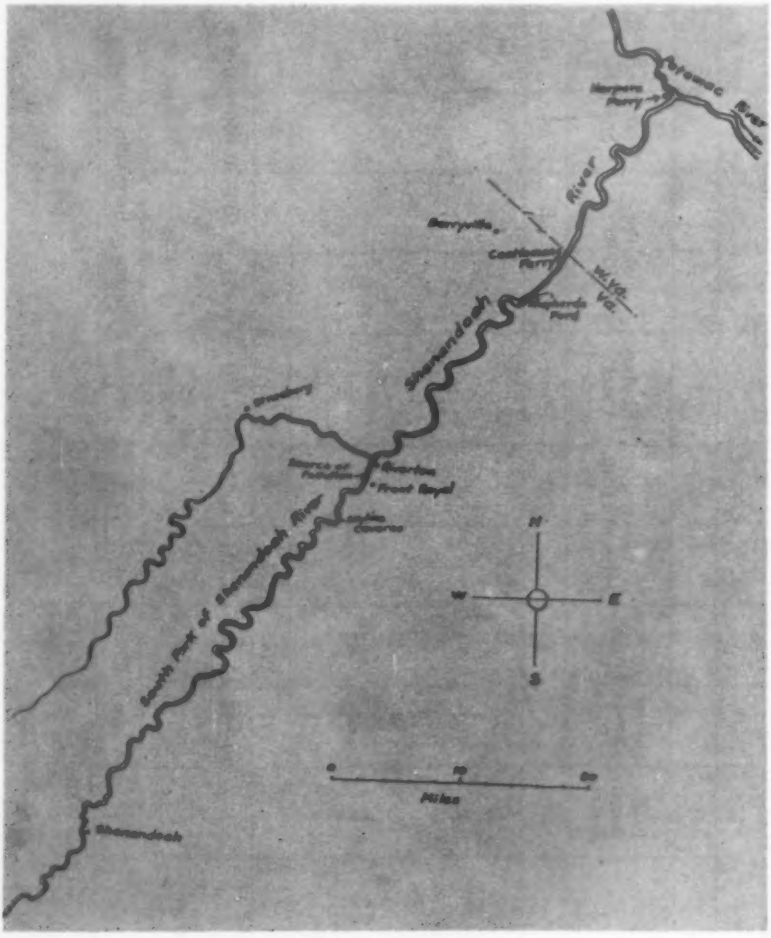


FIG. 3. The Shenandoah River.

The destruction which was later shown to have been brought about by a small amount of zinc (Henderson 1949) in the wastes of the great industrial plant at Front Royal is illustrated here because it is typical of destructive inorganic chemical wastes, and it is dramatic since it

shows a 96.5 per cent reduction in average number of animals per square foot above Front Royal at (Skyline Caverns) station 1 over the combined averages for the Berryville section stations 2–7 located above Castleman's Ferry 30 miles below the source of pollution. The aquatic life in 60 miles of river, the entire length of the Shenandoah River, was destroyed in this case. When the great reduction in aquatic life was revealed to the authorities of the public, a series of rather violent repercussions followed which after 10 years led to the restoration of the stream.

But apparently where some animals such as muskrats leave a river because of the conditions created by pollution others may be attracted to it.

A paper mill at Watervliet, Michigan and a cannery and pickle factory at nearby Coloma, plus domestic wastes from both towns, created low oxygen in the Paw Paw River from Watervliet about 18 miles downstream to Benton Harbor. Zero or near zero oxygen conditions were found for 12.5 miles below the paper mill on September 2, 1953 by the Michigan Water Resources Commission. Conditions were so critical that aquatic earthworms belonging to the Family Tubificidae were more abundant at the water's edge than they were on the bottom a foot or more below the water surface. The aquatic earthworms at the water's edge formed an almost continuous red border for miles down the river below Coloma. In a trip down the river by canoe, September 1, of this year, ducks were continuously in sight. Turtles of several of the native species were unusually abundant and crayfish were numerous at the water's edge where they could keep their gills moist and feed upon the large numbers of aquatic earthworms there. It was presumed that the turtles, ducks and crayfish were numerous because of the unusual abundance of aquatic earth worms living both in the water at the very margin and on the mud banks kept thoroughly moist by capillary action.

Organic wastes sometimes create a superabundance of animals capable of living at zero or near zero oxygen conditions for some time. Besides aquatic earthworms in this river, bloodworms *Tendipes decorus* were found at one point on the Paw Paw River (at zero oxygen) at a rate of nearly 7,000 to the square foot. Here the larvae were alive in their normal habitat on the bottom, but both living and dead individuals were seen drifting by in the water.

These are only a few examples, but a great and interesting job lies ahead for aquatic biologists to determine not only what conditions exist in our streams and lakes today but to estimate the damage that has already taken place.

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A Seminar Workshop

## THE TEACHING OF THE NATURAL SCIENCES IN RELATION TO RELIGIOUS CONCEPTS

In the belief that one of the great problems of the modern world is the tendency of people to give up moral, ethical, and religious standards and values as they acquire knowledge and understanding of the foundations of the natural sciences, the Danforth Foundation, in cooperation with the Summer Sessions at The Pennsylvania State University, is sponsoring a 1954 Summer Sessions Workshop on The Teaching of the Natural Sciences in Relation to Religious Concepts. Natural science teachers with a background and a working interest in such problems will, it seems, play a larger and larger part in the direction of social forces as their special capabilities become more in demand. This workshop will be held on the campus of The Pennsylvania State University for two weeks, including Saturday, beginning July 6, 1954. Registration will take place the evening of July 5, from 7:00 P.M. to 9:00 P.M.

Through the cooperation of the Danforth Foundation, Inc., twenty-five full scholarships, covering fees, board and lodging, are available for qualified applicants. For further information, write Dr. W. C. Fernelius, Department of Chemistry, The Pennsylvania State University, State College, Pennsylvania, Attention: Danforth Scholarship Committee. Each applicant for a scholarship should also include a brief statement of his academic background, his teaching experience, and the way he anticipates that he may be able to make future use of the benefits derived through attendance at the seminar-workshop.

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## NEW CARS FOR NEW YORK SUBWAY

More than $3 million worth of electrical equipment is being built by Westinghouse Electric Corporation for 100 new subway cars for the New York Transit Authority. The order was placed recently by the American Car and Foundry Company, builders of the cars.

Each car will be powered by four 100-horsepower, spring-suspended motors, operating on a 600-volt direct current third rail system.

Improved control systems for the 400-horsepower cars will provide smoother and faster acceleration and deceleration. Dynamic braking will be used to bring the trains to a smooth stop, and as a result of reduced brake-shoe wear, will mean much cleaner operation because of a corresponding reduction in brake-shoe dust.

The cars will be illuminated with fluorescent lighting. Additional passenger comfort will result from improved ventilation provided by six Westinghouse Axiflow fans in each car. Automatic thermostats will control the ventilating fans and heaters.

# THE MATHEMATICS TEACHER LENDS A HAND

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Eric Temple Bell has called mathematics the "Queen of the Sciences." She is certainly one of science's most efficient handmaids. I wish to stress here today the opportunities of the teacher of elementary mathematics to serve the budding scientist. However, I want to make it clear at the outset that I am not advocating a purely utilitarian approach to the presentation of mathematics at any level. I recall the words William Betz has written in the *Mathematics Teacher:* "... whenever mathematics became merely a tool for the solution of every day problems as in the days of ancient Egypt and of Rome, complete stagnation was the invariable result."

Arithmetic involves *quantitative* thinking, but this aspect is often overlooked. It should be simple to train the child from his early years to form some idea of the approximate size of the quantities involved before he works for an exact solution. A very simple example occurs in teaching multiplication involving the use of decimals. For example, 3.52 is to be multiplied by 4.6. If the child thinks in such fashion as: 3.52 is greater than 3 but less than 4, and 4.6 is greater than 4 but less than 5, therefore the product will be greater than 12 ($4\times3$) but less than 20 ($4\times5$), he should find it simple to write his answer as 16.192. When students are accustomed to think quantitatively, they will be slower to accept absurd results.

We can start this quantitative thinking with purely numerical examples involving the fundamental operations, but we must be sure to carry it over to word problems—always asking, "Is the result reasonable from a quantitative point of view?" This should bear fruit, for instance, when accident prevention is studied in general science. The distance necessary to stop a certain car going at different speeds may be found by using the formula $20d=s^2$, where $d$ is the stopping distance in feet and $s$ is the speed in miles per hour. (Incidentally, the alert student, trained to quantitative thinking, may discover an error or two in tables using this formula in at least one modern arithmetic text!) Quantitative thinking should also make the idea of *dimension* in physics easier to grasp.

Closely allied to quantitative thinking is an appreciation of geometric form and space perception. I think that the intuitive geometry of the plane is well-handled on the junior high school level, though here again is an opportunity for quantitative thinking in getting an estimate of how big (or how small) an acre really is—what *is* a mile, etc. Space perception, on the other hand, has been woefully neglected. The child is given some notion of the regular solids, but to visualize

the results when planes are passed through these solids at various angles is almost unheard of.

Models of clay through which planes can be passed by cutting with a knife will be interesting and instructive. Especially should the sphere be studied, and the idea of *great* circles made clear. Circles of longitude and latitude can be shown on the clay models, and the concepts of latitude, longitude, and time zones will be thus clarified.

I advocate that teachers in the Chicago area sponsor class trips to the Museum of Science and Industry; among other things the string models through which rays of light may be passed to form different curves will be sufficient reward for the trip.

Ability to visualize three-dimensional figures presented as plane drawings will be very useful to the general science student when he encounters the many diagrams in the ordinary general science text.

Symbolic representation includes graphs of various kinds. Ability to read and to interpret picture graphs, bar graphs, and circle graphs should be developed during arithmetic lessons. Graphs showing functional relationships require more careful preparation on the part of the mathematics teacher. I think that two distinct types of knowledge enter into this. One is the ability to see special laws derived from general relationships and vice versa, and the other is facility in using certain scales.

One should consciously exercise the ability to see special laws as derived from general relationships. Barnett Rich in the *Mathematics Teacher* for March, 1952, reports on the usefulness of the general relationship

$$xy=z.$$

He points out that this underlies such problems as finding areas of rectangles, motion at constant speed, solving mixture, percentage, lever, pressure-volume problems, etc. If the teacher is himself conscious of such generalities, he can at least hope that some of his students will glimpse the general law under any particular case.

Facility in using certain scales makes function graphs easier to read. The meter stick, yard stick, centigrade and Fahrenheit thermometers can be used to advantage by the mathematics teacher. The meter stick is an invaluable ally of the mathematics teacher from the time he first begins to teach decimal fractions. Facility in reading such numbers as 2.3, 10.7, 98.5 can be readily gained from the meter stick. Then considering that 1 cm.=.01 meter, it is not too difficult to teach the meaning of 0.03 (3 on the meter stick means either 3 centimeters or 0.03 meter), 0.175, 0.5, 0.675 by comparing 3 cm., 17.5 cm., 50 cm., 67.5 cm., with 100 cm. The decimal and fractional equivalents: $0.5=\frac{1}{2}$, $0.25=\frac{1}{4}$, etc., can be easily demonstrated in the same way.

Many meter sticks are scaled in inches on the reverse side. Measurements can be taken both in centimeters and in inches and the results compared. This will help to fix the tables of conversion from our inches-feet-yards system to the metric system.

A study of temperature belongs to the general science class. However, a study of the centigrade and Fahrenheit thermometers as scales presents a fine opportunity to the mathematics teacher to teach straight line graphs. Set up Fahrenheit readings on the horizontal scale, and centigrade readings on the vertical scale. Through the boiling point of water on the centigrade scale (100°) pass a horizontal line. Through the boiling point of water on the Fahrenheit scale (212°) pass a vertical line. These two lines meet in a point on the graph. The horizontal line through the freezing point of water on the centigrade scale (0°) will meet the vertical line through the freezing point of water on the Fahrenheit scale (32°) in a second point (on the horizontal axis). These two points determine the straight line which is the desired graph.

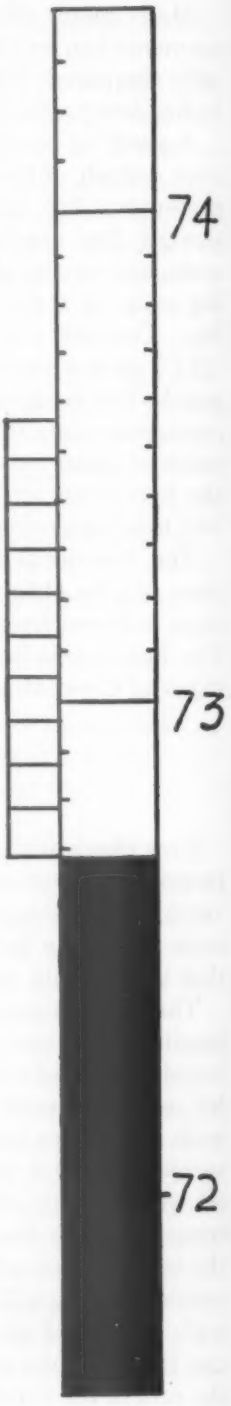
The functional relationship or formula connecting the two systems can be obtained thus: On the Fahrenheit scale there are 180 steps between freezing and boiling; on the centigrade, there are 100. The Fahrenheit freezing point is already 32°. If F = Fahrenheit reading, and C = centigrade reading, we can write the proportion:

$$\frac{F-32}{180}=\frac{C}{100}.$$

Now check with the graph that a point $P$ on the line satisfies this proportion if you call $F$ the value on the Fahrenheit scale where the vertical line through $P$ cuts it, and call $C$ the value on the centigrade scale where the horizontal line through $P$ cuts that scale. Also note that the formula can be written $\frac{5}{9}(F-32)=C$ — a form of $xy=z$!

The use of a vernier with a linear scale makes a topic that is challenging to the student and that will prove useful to him when he is learning to read a barometer. The vernier, as you know, is a device for reading a scale with greater accuracy than the divisions of the scale afford. For instance, if the scale is in tenths of a centimeter, the vernier will be a slide 0.9 cm. in length, marked off in tenths. It is set with the zero at the required reading; the lines of the vernier are compared with the division lines on the scale. One and only one of the vernier lines will correspond exactly with a line on the scale. The vernier reading will then given the exact number of hundredths of the scale reading. Each division of the vernier is (in this example) 0.09 cm. If the vernier reading of 7 matches with a line on the scale, when the zero of the vernier is just above 72.6 on the scale, the true reading

is 72.67. (The scale line matching the vernier is 73.3 and $73.3-0.63=72.67$.) In other words, one can simply annex the vernier reading to the 72.6 and have the more accurate reading 72.67. (See figure.)




What further help can the mathematics teacher give to his students who are heading for general science? He can teach them something about exponents, so useful in studying some biological processes. From this he can go on to give them some experience with the slide rule. It will be interesting and instructive to the students to help them construct their own slide rule. Several articles on the making of slide rules have appeared in recent years. From a study of them, I have decided on the plan I would use.

First I would review exponents somewhat as follows:

$$10^1=10$$
$$10^2=10\times10=100$$
$$10^3=10\times10\times10=1000.$$

Mathematicians have agreed to write the above equalities in this form: $\log 10=1$, $\log 100=2$, $\log 1000=3$. They have also agreed to write $10^0=1$ and so $\log 1=0$, $\sqrt{10}=(10)^{1/2}=10)^{.5}=3.162\ldots$ (the class will work out this square root) and so $\log 3.162=0.5$.

Now notice the fact that $10^2\times10^3=100\times1000=100{,}000=10^5$. (We could have had the result at once by simply adding the exponents.) Thus we can write $\log(100\times1000)=\log 100+\log 1000=2+3=5$. Also

$$\log\frac{100000}{1000}=\log 100000-\log 1000=5-3=2.$$

Mathematicians (I would explain) have prepared tables of logarithms for us, from them we can read:

$$\log 2=0.301;\ \log 3=0.477;\ \log 7=0.845.$$

We could read $\log 5$ from the table, but it will be more fun to obtain it by using

$$\log 5=\log\frac{10}{2}=\log 10-\log 2=1.000-0.301=0.699.$$

Put masking tape along two meter sticks (being careful not to cover up the divisions). (Or draw a line on the blackboard in place of one of the meter sticks.) Because log 1=0 and log 10=1, we will call the starting point 1 and the end point 10. At 0.301 m. (30.1 cm.) mark 2, at 47.7 cm. mark 3 on the masking tape. 4 will be marked 0.301 m. beyond 2 (why?) and 6 will be 0.301 m. beyond 3. Similarly the other points are located.

By adding log 3 and log 4, we should be able to locate log 12. Since this extends beyond the meter stick, it would help at this point to use a line on the blackboard to explain where 1.2 will fall on the meter sticks. At this time, also, it will be well to introduce a ready-made slide rule, and explain the abbreviations used in its marking. Then let the students multiply 3 by 6, 4 by 12, etc. Show them that they have to use their quantitative thinking in deciding whether their answers should be called 1.8, 18, 180 in the one case, and 4.8, 48, or 480 in the other. In other words, we have gone full circle and are back to our plea for teaching quantitative thinking! I only hope we mathematics teachers wont be too disappointed if, after all our endeavors, our science teacher friends still find they have to be good mathematicians too to keep their budding scientists on the straight and narrow but rewarding path that leads to mathematical and scientific power.

## READING LIST

The following is meant to be suggestive, rather than exhaustive. In particular, few references are given to articles in SCHOOL SCIENCE AND MATHEMATICS because it is assumed that the members of CASMT are all familiar with this magazine.


Berger, E. J. "Devices for a Mathematics Laboratory," *Mathematics Teacher*, 45: 217, March, 1952.

Betz, Wm. "Place of Mathematics in Human Affairs and Related Curriculum Problems," *Mathematics Teacher*, 45: 81–8. Feb., 1952.

Cooper, C. G. "Mathematics in Engineering Research," *Mathematics Teacher*, 45: 331–5, May, 1952.

Gray, Mrs. J. T. "Historically Speaking," SCHOOL SCIENCE AND MATHEMATICS, 52: 345–55, May, 1952.

Grove, Ethel L. and Ewart, L. "An Experiment in the Integration of Mathematics and Science," SCHOOL SCIENCE AND MATHEMATICS, 52: 467–70, June, 1952.

Jansen, H. S. "Relation of Mathematics to a Core Curriculum," *Mathematics Teacher*, 45: 427–35. October, 1952.

Johnson, J. T. "Use of a Ruler in Teaching Place Value in Numbers," *Mathematics Teacher*, 45: 264–6, April, 1952.

Kinsella, J. J. "Research in Mathematics Education"; (a study of Barnett Rich's Ph.D. dissertation on variation), *Mathematics Teacher*, 45: 352–3, May, 1952.

Meyer, J. S. *Fun with Mathematics*. World Book Co., Yonkers, N. Y. 1952.

*National Council of Teachers of Mathematics, Twentieth Yearbook: Metric System of Weights and Measures*, Teachers College, N. Y., 1948.

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Prag, L. D. "Devices for Teaching Logarithms," *Mathematics Teacher*, 45: 378–80, May, 1952.

Reeve, W. D. "The Place of Mathematics in Secondary Education," School Science and Mathematics, 53: 273–85; 375–86, April, May, 1952.
Schaaf, W. L., ed. *Mathematics Our Great Heritage.* Harper & Bros., New York, 1948.
Wilson, J. D. "Mathematics: a Must for the Mechanic," *Mathematics Teacher,* 45: 27–9, January, 1952.

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# A STUDY OF THE PERFORMANCE OF A GROUP OF SELECTED COLLEGE FRESHMEN ON THE NATIONAL ACHIEVEMENT STANDARDIZED GENERAL SCIENCE TEST

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## The Problem

This study deals with entering college freshmen in the Summer Session of 1953 at Southern University. Its purposes were: (1) to ascertain the extent to which these students have mastered subject-matter content in general science; and (2) to make use of the data as a means of improving a physical science course, taught by the writer, in order to meet the present needs of the students.

## Method and Procedure

The National Achievement Standardized General Science Test was administered to 60 male and 85 female students. The General Science Test was designed for grades 7–9 inclusive. This text was selected because it measured: (1) the student's knowledge of scientific concepts; (2) his ability to identify objects from illustrations to recognize the important men of science; (3) his ability to define scientific facts. The students had as much time as wanted for completion of the test. All tests were given and scored by the writer.

## High School

The one-hundred and forty-five selected college freshmen were from fifty-one high schools, two parochial high schools in the state of Louisiana, and two public high schools in the state of Mississippi. Of the sixty male students, six were graduated valedictorians, two were graduated salutatorians, and three were honor students in their respective high school classes. Nine of the female students were graduated valedictorians, two were graduated salutatorians, and three were honor students.

## High School Science Background

Table I shows that the majority of the students, both male and fe-

male have had all of the science courses listed save chemistry and physics.

TABLE I. HIGH SCHOOL SCIENCE COURSES TAKEN BY PARTICIPATING STUDENTS

| Subjects | Males | | Females | |
|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent |
| General Science | 52 | 86.66 | 69 | 81.17 |
| Biology | 55 | 91.66 | 77 | 90.58 |
| Algebra | 54 | 90.00 | 77 | 90.58 |
| Chemistry | 31 | 51.66 | 56 | 65.88 |
| Physics | 4 | 6.66 | 4 | 4.71 |
| Geometry | 51 | 85.00 | 70 | 82.35 |
| General Mathematics | 55 | 91.66 | 75 | 88.24 |

## RESULTS

Table II shows that the scores on the General Science Test for the entire group, both male and female students, range from 14–96. The highest possible score on the test is 120. The National median, 73, is for students in the ninth month of the ninth grade. It is apparent from Table II that the group mean—males and females—is much below the National norm. The mean of the total group is also below the National norm. The majority of students, males and females, earned scores below the National norm on the standardized test.

TABLE II. FREQUENCY DISTRIBUTION OF THE SCORES AND THE COMPARISON OF NORMS BY SEX[1]

| *Males* | | | *Females* | | | *Means* | | | |
|---|---|---|---|---|---|---|---|---|---|
| Score Range | Frequency | Per Cent | Score Range | Frequency | Per Cent | National[2] | Males[3] | Females[3] | Total Group[4] |
| 86–96 | 3 | 5.00 | 80–90 | 1 | 1.18 | 73 | 49.01 | 46.93 | 47.79 |
| 75–85 | 3 | 5.00 | 69–79 | 3 | 3.53 | | | | |
| 64–74 | 2 | 3.33 | 58–68 | 13 | 15.29 | | | | |
| 53–63 | 12 | 20.00 | 47–57 | 30 | 35.29 | | | | |
| 42–52 | 18 | 30.00 | 36–46 | 21 | 24.71 | | | | |
| 31–41 | 17 | 28.33 | 25–35 | 14 | 16.47 | | | | |
| 20–30 | 5 | 8.33 | 14–24 | 3 | 3.53 | | | | |
| Total | 60 | 100.00 | Total | 85 | 100.00 | | | | |

The National norm for high school students for the seventh month to the ninth month of the seventh grade is 46–49 inclusive. When one compares the medians of the males and females plus that of the entire group with the National median, it is apparent that the students are at seventh grade level in mastery of subject-matter content in general science.

[1] Highest possible score is 120 points.

[2] 73 is the National average score for pupils in the ninth month of the ninth grade.

[3] Based on the total frequency of the grades by the group.

[4] Mean of both males and females based on the scores of the total group.

Of the honor students, the scores were 95, 91, 74, 63, 60, 57, 49, 46,

36, and 35. For the female honor students the scores were 87, 70, 69, 67, 62, 61, 58, 56, 44, and 33.

Table III gives a clearer picture, by subject-matter areas, of the strong and weak points of one-hundred and forty-five selected college freshmen. For convenience, the questions asked on the test were placed in the following manner by subject-matter areas: Astronomy (Motions of the earth, planets, daylight, telescopes); Geology (Soil, fossils); Meteorology (Weather); Chemistry (Scientific experiment, scientific law, evaporation, vitamins, humidity, precipitation, states of matter, decomposition, linen, chemical actions, foods, oxidation, water, gases); Physics (Kinetic energy, lever, magnets, sound, floating bodies, spectrum, light bulb, telegraph, locomotive, steamboat, telephone, dynamo, gravitation, heat, measuring time, camera, compass, density, speedometer, weight, electricity, thermometers, friction); Biology (Evolution, heredity, assimilation, bean, alimentary canal, disease, vaccination, plants, animals, insects, blood, respiration, birds, pollination, digestion, reproduction).

TABLE III. NUMBER AND PER CENT OF CORRECTLY ANSWERED QUESTIONS BY SUBJECT-MATTER ON THE GENERAL SCIENCE TEST

| | *Males* | | | | | *Females* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Subject-matter Areas | Number of Students | Number of Questions Asked | Maximum-Possible Number of Correct Answers | Number of Correct Answers | Per Cent Correct Answers | Number of Students | Number of Questions Asked | Maximum Possible Number of Correct Answers | Number of Correct Answers | Per Cent of Correct Answers |
| Physical Sciences other than Physics and Chemistry (Astronomy, Geology, & Meteorology) | 60 | 10 | 600 | 282 | 47.0 | 85 | 10 | 850 | 393 | 46.24 |
| Physis | | 42 | 2,520 | 952 | 37.7 | | 42 | 3,570 | 1,135 | 31.8 |
| Chemistry | | 27 | 1,620 | 609 | 37.5 | | 27 | 2,295 | 959 | 41.7 |
| Biology | | 41 | 2,460 | 1,004 | 40.8 | | 41 | 3,485 | 1,491 | 42.7 |
| Total | 60 | 120 | 7,200 | 2,847 | 39.54[1] | 85 | 120 | 10,200 | 3,978 | 39.0[1] |

[1] Per Cent for the total number of questions answered correctly and the total number of questions answered by subject-matter areas.

## CONCLUSIONS

The important conclusions derived from this investigation were:

1. The majority of all the students participating in this study had courses in

General Science, Biology, Algebra, Geometry, and General Mathematics.
2. Small number of male and female students had a course in Physics.
3. More than half of the male and female students had a course in Chemistry.
4. Less than 13.33 per cent of the male students and less than 4.71 per cent of the female students made scores equal to or better than the National norm for students in the ninth month of the ninth grade.
5. The mean score for the male students was 49.01 and for the female students 46.93. The median for the entire group—both males and females—was 47.79. A comparison of these medians with the National median shows that the majority of the students participating in the study had reached the seventh grade in mastery of subject-matter content in General Science.
6. Twenty per cent of the female students and less than 36.66 per cent of the male students made scores below the National norm for students who were beginning the seventh grade. The National median for beginning students in the seventh grade is 38.
7. The students reflected little knowledge of the physics, chemistry, biology and the other physical sciences (astronomy, geology, and meteorology). Of the total number of questions answered only 39.2 per cent of them were answered correctly.

## Recommendations

The data in this study reveal that there is a great need to raise the general education in science for students based on the results in Table III. Insofar as the results of this investigation may be valid, the following recommendations seem justified:

1. That an introductory course in the physical sciences be included in the general education program of the college. The course in Physical Science must be one that is dedicated to the presentation of fundamental concepts and theories. It seems logical to assume that such a course might insure amelioration of the *status quo*.
2. That an introductory course in the biological sciences be included in the general education program of the college. It appears that introductory courses in both the physical and biological sciences would enable those students who will go no further in the sciences to have an appreciation for their scientific environment.
3. That research studies in the area of subject-matter content for general education science courses be made so as to determine long-term values to be secured by the student.

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## RIDER RELEASES *RADIO TROUBLESHOOTING GUIDEBOOK*

Volume I of the *Radio Troubleshooting Guidebook* series written by John F. Rider and J. Richard Johnson has just been published by John F. Rider Publisher, Inc. of 480 Canal Street, N. Y. 13, N. Y. It is being shipped to Rider distributors and book stores.

*Radio Troubleshooting Guidebook* Volume I is a reference text for radio repair technicians, students of electronics and all others who are concerned with maintenance operations on these equipments. It is the first volume of a series which will cover every aspect of radio receiver repair, beginning with the explanation of how radio receivers work to the treatment of every kind of defect which may develop in them. It is the kind of information which can be turned into dollars every day.

The book contains 150 pages of useful, practical information, written in an easy-to-follow and understanding style. The book is paper covered, is $5\frac{1}{2}'' \times 8\frac{1}{2}''$ and sells for $2.40.

# A PROOF OF THE LAW OF COSINES

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On the side $BC(=a)$ of triangle $ABC$ as diameter describe a circle which intersects the sides $BA(=c)$ and $CA(=b)$, produced if necessary, in $D$ and $E$, respectively. Then from the right triangles thus determined, we have

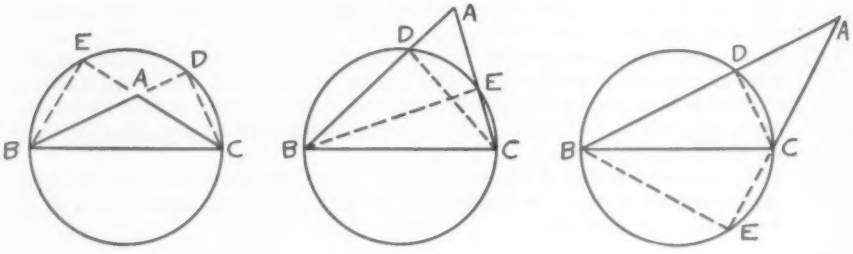
$$a^2=(CE)^2+(BE)^2 \qquad a^2=(BD)^2+(CD)^2$$
$$c^2=(AE)^2+(BE)^2 \qquad b^2=(CD)^2+(AD)^2$$

When the sum of the last two equations is subtracted from the sum of the first two equations,

$$\begin{aligned}2a^2&=c^2+(BD)^2-(AD)^2+b^2+(CE)^2-(AE)^2\\&=c^2+(BD+AD)(BD-AD)+b^2+(CE+AE)(CE-AE)\\&=c(c+BD+AD)+b(b+CE+AE)\\&=2c(BD)+2b(CE),\end{aligned}$$

where directed lines have been used in order to include all possible cases. Hence

$$a^2=c(BD)+b(CE). \tag{1}$$




Now from the theorems regarding segments of intersecting chords and of intersecting secants,

$$0=c(AD)+b(AE)-2b(AE). \tag{2}$$

It follows, by subtracting (2) from (1), that

$$\begin{aligned}a^2&=c(BD-AD)+b(CE-AE)-2b(EA)\\&=c^2+b^2-2b(EA).\end{aligned}$$

When $A$ is acute, so that its vertex falls outside the circle, $EA=c\cos A$. When $A$ is obtuse, so that the triangle falls wholly within the circle, $EA=-c\cos(180°-A)=c\cos A$. Therefore, in general,

$$a^2=b^2+c^2-2bc\cos A.$$

# NEW BOOKS FOR THE HIGH SCHOOL SCIENCE SHELF

LOUIS PANUSH
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In the past few years considerable attention has been given to the problem of reading by and for science students. Science teachers realize, as do teachers in other fields, that reading is for many students one of the most fruitful of all learning experiences. Many feel that in science classes at the secondary level students should not only be encouraged but required to do a certain amount of suplementary reading. Although television, radio, comics, and movies take away much "free reading" time from the average boy and girl, there are still many hours available for good reading; and the average high school student is accessible to books in the school or community library. Judicious reading of the growing science literature, in addition to textbook material, for entertainment, scientific information, scientific thinking, and for the simple pleasure and joy of reading, will prove a worthwhile and fruitful experience and another effective means of instruction in science.

This *Journal* has published in previous years an annual annotated list by Dr. Paul Kambly of the best books written on the elementary science level. Except for occasional reviews in the book section, there was no such list of science books on the secondary level. Every year several hundred new books appear in the field of science for high school students and for the general reader. Some are excellent, others are poor; some are for the mature and outstanding science student, many for the average and some for the subaverage reader. In compiling this partial list[1] of science books published in 1953, in order to present them for the consideration of science teachers for the science shelf of the high school and community libraries, the author was guided by a list of characteristics suggested by Professor Hanor A. Webb:[2]

1. The books should be diversified.
2. They should have a wide range of reading level.
3. They should meet instincts of high school youth.
4. Some should be for vocational guidance.
5. Some should be of reference value.

## Astronomy

*The End of the World.* By Kenneth Heuer. 220 pp. Illustrated. Rinehart. $3.00.

[1] This is a part—brought up-to-date—of the more comprehensive (1950–1953) list which the author presented at the meeting of the Chemistry Section of the CASMT convention, on Friday, November 27, 1953.

[2] "The High School Science Library," by Hanor A. Webb, *The Science Teacher*, March, 1951, pp. 66–68.

An extremely interesting scientific inquiry which summarizes the speculations of astronomers and physicists on how the world may actually come to an end: by a direct hit by a comet, a head-on meeting with an asteroid, the explosion of the sun, the death of the sun, or by atomic war. Also what will happen on the day of doom to the earth and to life upon it. More exciting reading than science fiction, based on scientific knowledge and authority, and hopeful conclusions as to the ultimate fate of the earth.

*The Moon.* By George Gamow. 120 pp. Illustrated. Henry Schuman. $2.50.

The story of earth's satellite, its characteristic movements, its laws of gravity and tides, eclipses, selenography, and what is known about it from studies through various telescopes. The author, a well-known physicist and astronomer, takes his readers on an imaginary trip to the moon a lá Jules Verne. Thoroughly enjoyable and informative.

*The Complete Book of Outer Space.* Edited by Jeffrey Logan. 144 pp. Illustrated. Gnome Press. $2.50.

A book full of unusual and informative material on a speculative subject which will give the interested reader (and there are very many among the high school age group) a kind of a preview of the future. Rather than to recommend science fiction to our students, it will be much more worthwhile for them to read what the experts have to tell of what is being done in the field, of their progess and their hopes—in this serious yet dramatic presentation in pictures and text.

*Your Trip into Space.* By Lynn Poole. 274 pp. Illustrated. Whittlesey House, McGraw-Hill. $2.75.

The latest scientific knowledge regarding the fascinating subject of space travel: what it means, what dangers are involved, the rockets that will be used and the fuels to fire them, the launching and take-off of rockets, space stations, a return trip to the moon, and a prediction that man will fly into space within fifty years. Written by the producer of the Johns Hopkins TV Science Review. More understandable to the general high school student than the preceding volume described.

*The Stars Are Yours.* By James Sayre Pickering. Revised edition. 300 pp. Illustrated. Macmillan. $3.95.

The author, Special Lecturer at the Hayden Planetarium, takes his readers on an exciting tour of the starry universe without requiring of them special scientific background. A lucid explanation of our solar system, our galaxy, and the galaxies beyond. Twenty-four up-to-date charts will serve as guides on a visual exploration of the heavens.

## Atomics and Electronics

*The Atom Story.* By J. G. Feinberg. 244 pp. Illustrated. Philosophical Library. $4.75.

Few books written in recent years on the atomic story will match Dr. Feinberg's volume in clarity, readability, and the highly interesting exposition. It popularizes science in a manner which will appeal to teacher and student, scientist and layman. The story begins with Democritus and continues step-by-step along a journey of adventure and discovery to the very present. The last two chapters deal realistically with the atom and the human race in war and peace. Contains many unconventional drawings which do an excellent explanatory job. Highly recommended for the science shelf.

*Electronics Everywhere.* By A. M. Low. 195 pp. Illustrated. John Day. $2.50.

A readable and interesting account of the science of electronics and its many uses in our modern world, written by a well-known British scientist and author of popularizing science books.

*Report on the Atom.* By Gordon Dean. Alfred Knopf. $5.00.

An up-to-the-minute account of our program of atomic development for both military and peaceful purposes, by the recently retired chairman of the

U. S. Atomic Energy Commission. It also discloses Russia's atomic program and gives an outlook for future progress.

### Biographies

*An American in Europe: The Life of Benjamin Thompson, Count Rumford.* By Egon Larsen. 225 pp. Illustrated. Philosophical Library. $4.75.

A very readable biography of a research scientist (whom students encounter in the study of heat) who has to his credit these achievements: pioneer of domestic science, "creator" of the modern theory of heat, inventor of the non-smoking fireplace, social reformer, "discoverer" of Humphrey Davy, nutrition expert, etc.

*Men Who Changed the World.* By Egon Larsen. 2nd edition. 244 pp. Illustrated. Roy, Publishers. $3.00.

Twelve interestingly written biographies of great scientists and inventors whose inventions or discoveries "have changed the way we live in the last seventy years." Among them: Bell, Edison, Dunlop (pneumatic tires), Marconi, the Wright brothers, Ford, Lord Rutherford, Robert Watson-Watt, and others. Enjoyable and informative reading which portrays a picture of scientific progress in today's world.

*Andrew Carnegie.* By Alvin Harrow. 182 pp. Julian Messner. $2.75.

The life story of a poor immigrant boy who became one of America's leading industrialists, the founder of a great steel empire—the profits of which he used to endow colleges, museums and educational institutions. Interesting information on the "Age of Steel."

*J. Robert Oppenheimer and the Atomic Story.* By A. Alvin Kugelmass. 180 pp. Illustrated. Julian Messner. $2.75.

An exciting biography of the "man who built the atomic bomb," a pioneer of the Atomic Age. Woven in the story are the dramatic incidents which led to the development of atomic energy, a meaningful description of what atomic energy is and what it means to mankind, and the story of the Institute for Advanced Study in Princeton, N. J.

*William Crawford Gorgas.* By Beryl Williams. 184 pp. Illustrated. Julian Messner. $2.75.

The life story and accomplishments of the man whose courage and persistence conquered one of man's dreaded diseases—yellow fever. Of pertinent interest when studying the unit on diseases.

### Biology

*Life on Earth.* By Rose Wyler and Gerald Ames. 160 pp. Illustrated. Henry Schuman. $2.00.

The authors trace the remarkable story of the development of life from the smallest and earliest forms to the Age of Man. Covers a wide field in a most interesting and instructive manner.

*Between the Tides.* By Philip Street. 175 pp. Illustrated. Philosophical Library. $4.75.

Describes the abundance of life which may be found underneath a boulder on the shore or in the strands of seaweed in a rock pool. Excellent black and white photographs, taken by the author, add to the well-told story.

*Ways of Mammals in Fact and Fancy.* By Clifford B. Moore. 271 pp. Ronald Press. $3.50.

A vivid account of the fascinating, yet often misunderstood behavior of mammals based upon authentic information gathered by the author who is the Director of the Forest Park Museum at Springfield, Mass. Clears many of the misconceptions, superstitions and myths about the animal world which have persisted from the past.

*The Social Insects.* By O. W. Richards. 200 pp. Illustrated. Philosophical Library. $4.75.

Much has been written about the social communities of the insect world, yet this volume by a British entomologist is a fine contribution to the literature. The descriptions of bees, wasps, ants and termites are non-technical but scientifically accurate. Excellent black and white photographs add to the value of this readable book.

*Reptiles and Amphibians*. By Herbert S. Zim and Hobart M. Smith. 160 pp. Simon and Schuster. $1.50.

The sixth and newest in the excellent series of *Golden Nature Guides* is almost a complete handbook of most of the reptiles and amphibians of the United States. Each page carries a colorful picture of the animal, a range map, and succinct and accurate information about it. The whole series is highly recommended for biology classes and the private use of students.

*Trees and Trails*. By Clarence J. Hylander. 252 pp. Illustrated. Macmillan. $3.00.

The second in a series by the author intended to give a background in natural science. It gives a lot of information about 150 different trees, their botanical parts and identifying features, and how their characteristics are related to the environment in which they live. A little on the dull side, but good for reference and reports.

*Our Wildlife Legacy*. By Durward L. Allen. 422 pp. Illustrated. Funk & Wagnalls. $5.00.

A vivid and readable account of one of America's great national resources and the principles underlying its management. Since wildlife is a renewable resource that must be managed wisely if we are to have continued benefits from it a sound understanding of problems and issues involved will lead to intelligent solutions and management. This book will provide the background, for both student and teacher, for a better understanding of wildlife conservation.

*Curious Creatures*. By Erna Pinner. 256 pp. Illustrated. Philosophical Library. $4.75.

An extremely interesting and informative book which describes the curiosities of the animal kingdom, such as curious behavior in the struggle for food, nest building, paternal nursing, water creatures that breathe air, birds that cannot fly and four-footed animals that can, giants of the animal world, strange forms of animal camouflage, symbiosis and parasitism, creatures that live upside down or are fantastically shaped. We find that nature has no bounds in invention of oddities in the animal world and that there is a good reason for this versatile and strange display.

## Chemistry

*Man and the Chemical Elements*. By J. Newton Friend. 355 pp. Illustrated. Scribner's Sons. $6.00.

In these pages, the science of chemistry is explored through the history, properties, compounds, and uses of its elements. The first chapter gives a general historical background of chemistry. This is followed by 22 more chapters describing the permanent gases, the inert gases, the halogens, and all the families of elements in the Periodic Table. Each chapter is an entity in itself and can be read with great profit by the student when he is studying that particular subject in his chemistry class. An excellent reference volume, interestingly written, and highly informative.

## Physics

*More Power to You*. By Herman and Nina Schneider. 128 pp. Illustrated. William R. Scott. $2.50.

A clearly told, informative story of power, from the days of the windmill to atomic energy and utilization of sunlight today. Included are a number of easy experiments and simple models which can be made out of materials at home. Although recommended for ages 12 to 14, it will be good reading for the

physical science and general physics student.

*What Makes the Wheels Go Round?* By Edward G. Huey. Illustrated. Harcourt, Brace. $3.00.

The revised edition of one of the best, yet simple introductions to physics for the physical science and general physics student.

### Physical Science—Earth Science—General Science

*Water, Miracle of Nature.* By Thomson King. 240 pp. Macmillan. $3.50.

A heterogeneous collection of facts about this plentiful and familiar liquid in nature, presented in an entertaining and informative manner. The author emphasizes the role which water plays in shaping the world and how the life of man and his welfare are inextricably bound to this universal liquid.

*Understanding Weather.* By T. Morris Longstreth. 120 pp. Macmillan. $2.50.

A revision of the author's earlier book, "Knowing the Weather," which includes the newer developments in meteorology of the last 10 years. It is a readable account of the fundamentals of weather and it tells the amateur enthusiast what tools he needs for his hobby. Has a bibliography and a glossary of technical terms.

*Flight Today and Tomorrow.* By Margaret O. Hyde. 145 pp. Illustrated. Whittlesey House, McGraw-Hill. $2.50.

An introduction to the principles of flight. Describes every move of the pilot from take-off to landing. Also tells about helicopters, gliders, transports, jet planes, and rockets. Simple experiments illustrate the fundamentals of aerodynamics.

*America Before Man.* By Elizabeth Chesley Baity. 225 pp. Illustrated. Viking. $3.75.

A highly interesting, descriptive account of the development of the physical features of the American continent and the evolution of life on it from one-celled plants and animals to the rise of mammals. Maps, diagrams, and excellent photographs supplement the lucid text.

### Scientific Adventure

*Explorations in Science.* By Waldemar Kaempffert. 300 pp. Viking. $3.50.

A description of some of the most recent researches and developments in science and how these have benefited and will benefit mankind, by the nationally known science writer and editor of the *New York Times.* Some of the topics discussed are: utilization of atomic energy, building an artificial satellite in space, "machine" hearts and lungs, regional control of weather, the 200-inch reflecting telescope of Palomar, the mystery zone of supersonic speed, can science create life, etc. Will keep the student informed on what is happening in science today.

*North, the Nature and Drama of the Polar World.* By Kaare Radahl. 240 pp. Illustrated. Harper. $3.50.

The thrilling story of personal adventure and discovery in the polar region, written by the man who helped plan and took part in the U. S. Air Force Island Project, T-3. Describes the vast sea which covers the top of the world and the animal life in the bleak and hostile arctic environment.

*Deep Down Under.* By John Floherty. 146 pp. Illustrated. J. B. Lippincott. $2.85.

A very interesting description of the men—and the methods they use—who explore the undersea world.

*The Rivers Ran East.* By Leonard Clark. 366 pp. Illustrated. Funk & Wagnalls. $5.00.

An extraordinary account of a great explorer's authentic adventure and discovery in the inner areas of darkness of the Gran Pajonal, east of the Peruvian Andes, and other inaccessible regions of the vast jungle of the Amazon country. It is simply and directly told, and it combines fascinating information with exciting adventure.

*Scientific American Reader*. 630 pp. Simon and Schuster. $6.00.

The 50-odd articles in this excellent anthology were originally published in the *Scientific American* during 1948–1952. Each of the twelve sections of this Reader deals with a general topic of current investigations in science: evolution of the universe, structure of the earth, structure of matter, origin of life, modern genetics, study and control of virus diseases, newest research in biology and medicine, animal behavior as it throws light on human behavior, origin and evolution of man, and understanding and appreciation of our rational processes, sensations and perceptions. All articles have in common the element of clarification of the basic problems in science. A must for the mature and superior student.

*Digging Beyond the Tigris*. By Linda Braidwood. 200 pp. Illustrated. Henry Schuman. $4.50.

The record of one of Mrs. Braidwood's archeological digging seasons in Jarmo, in the Kurdish Hills of Iraq, from its original planning stage to the actual field work and living among the natives. The personal element makes the story interesting reading.

General

*The Way of Science: Its Growth and Method*. By John Sommerville. 160 pp. Illustrated. Henry Schuman. $2.50.

A discussion of the historical growth of science, why we study science, the method basic to all science and how it works, the relation between natural and social science, the connection between science and art, and the future of science. A good descriptive introduction to the nature of scientific thinking and method.

*Science Fun with Milk Cartons*. By Herman and Nina Schneider. 160 pp. Illustrated. Whittlesey House, McGraw-Hill. $2.50.

This team of able authors shows that science can be fun by building many simple engineering models that work from ordinary milk cartons. Teaches basic science concepts and principles involved. Detailed directions and fine drawings make the job simple.

*Ships and Life Afloat: From Galley to Turbine*. By Walter Buehr. 120 pp. Illustrated. Scribner's Sons. $3.00.

An informative story about one invention of man, from its early beginnings to the most modern craft—its construction, rigging and armament, and the seaman and his life aboard ship. Also includes stories of some of the incredible voyages of great navigators. Beautifully printed and excellently illustrated.

*A World Full of Homes*. By William A. Burns. 120 pp. Illustrated. Whittlesey House, McGraw-Hill. $2.50.

The extremely interesting story of man's progress in building appropriate shelters from the days of cave dwellers to the modern American home of today. Includes a chapter about unusual homes around the world. Good reading for everyone, but especially for the general student.

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Wrench sets are packaged in a colored enameled holder which becomes a wall bracket for the wrenches when installed in the home workshop. Nine different sets are available, including five- and six-piece combination or box-end wrenches and 11- or 19-piece socket sets.

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Plastic extinguisher squirts a fire-fighting chemical from its clear, leak-proof bag. Having no metal parts to corrode, the bag is set for action when a ring is pulled. When squeezed, a spray nozzle squirts a stream of carbon tetrachloride 18 feet.

# TECHNICAL TRAINING APPLICATIONS*

H. M. BARNES

*Technical Training Division, Department of Industrial Education, Chrysler Corporation, Detroit, Mich.*

From the many experiences we meet daily we are constantly made aware of the way mathematics has become woven into the pattern of our way of life. One phase of this so-called way of life is our increasing reliance on industry and manufacturing. One segment of industrial activity is the technical field. Since the printed program assigns and limits me to a discussion of "technical applications," it may be well to define this segment broadly.

Without getting involved in specifics, we should restrict our concept of "technical" sufficiently to eliminate engineers and engineering. That is a broad field in itself and one in which mathematics plays a fundamental but essentially different role from what it plays in the technical area. We may begin by admitting that both engineers and men in the skilled trades work with their brains and their hands. Then we can differentiate by observing that the engineer's labors are predominantly mental, with physical activity serving mainly to collect or verify data to be used in analysis or computation, while the technical worker is trained to do things—make things with his hands—and his use of analysis and computation serve to guide this work. Thus the distinction is seen to be one of emphasis as well as application.

Before launching into an examination of the purpose, application, aims, and needs in the technical area, let us note briefly who is to develop mathematical skills among technical workers, particularly those in the skilled trades. This development must be a divided and continuing responsibility of many people. Due to the high degree of specialization required in meeting the needs of each trade, apprentice schools and programs of related training for apprentices must shoulder the responsibility for final training. But years of preparation inevitably precede such specialized training—potentially twelve years, but more often nine to eleven. The fundamental concepts and skills of arithmetic are imparted during these years and all specialized training in trade schools must be based on this background. Instructors in technical schools are eternally grateful for this groundwork of mathematical skill provided through the effects of competent teachers.

Let us suppose, now that a high school graduate has entered a typical apprentice program, such as the one we maintain at Chrysler.

* Presented at the Mathematics Section of the Central Association of Science and Mathematics Teachers at the Congress Hotel, Chicago, November 27, 1953.

Such a trainee will work in the shop with an experienced journeyman in his trade for a minimum of thirty-six hours per week, spend 2 hours in a theory class, and receive two hours of mathematics instruction. Here an attempt is made to indoctrinate the trainee with a sense of the purpose of mathematics in his trade. This purpose will vary slightly with the trade but mathematics generally serves two purposes in the trades: (1) As a direct tool for securing needed data, and (2) as a necessary background for comprehending technical functions. Perhaps a couple of specific examples will clarify and illustrate these two functions. A simple but characteristic example of the first might be a tool-maker calculating the elevation of a sine bar needed to produce an angle at which to machine a locating block. The other might be illustrated by an electrician's need for an understanding of the graphical representation of the sine curve in order to comprehend the characteristics of the cycles of A. C. electrical current. Or we might cite the need for a familiarity with vectors in order to understand how equipment and the circuits involved operate.

It has been found desirable, whenever mathematics is presented as a direct tool for arriving at dimensions needed to carry on a work project, to insist on correct and exact computation from each trainee right from the start, even at the risk of discouraging the beginner at first. He must come to realize that while a mathematics teacher in a more academic set-up can reasonably give partial credit for correct analysis, method, and procedure, no foreman is going to praise, or partially praise, the workman whose correct analysis, method and procedure, coupled with an error in addition, leads to the scrapping of a die or fixture into which have gone several thousand dollars worth of time, labor, and materials.

Since I am *most* familiar with details of the training programs at Chrysler, I shall use them for illustrative purposes. Those which include instruction in mathematics are: (1) the High School Co-op program in which 11th and 12th year students alternately spend two weeks in high school and two weeks at Chrysler where they work thirty-six hours per week in the machine shop and receive four hours of related training per week with two hours being devoted to mathematics (2) A general machine shop course for high school graduates. This course lasts 4000 hours, or about two years and includes two hours of theory and two hours of mathematics per week. (3) Four-year apprenticeships in such trades as toolmaking, diemaking, diesinking, die model building, body fixture building, sheet metal experimental, sheet metal and tin smith, machine repair, electrician, pipefitter-steamfitter-plumber, and millwright. Eight hundred hours of related training in each of these areas includes 400 hours of mathematics at the rate of two hours per week.

Inasmuch as the aim of this work is to provide the mathematical skills needed for the particular job or trade, their needs must be clearly analyzed and defined. Since such analysis and definition has been made the subject of volumes, and our time here is limited, I shall attempt to sum up the more common mathematical requirements for a man working in a tool room.

The *first* need is a background of arithmetic, with emphasis on common fractions. Most beginning trainees have what seems like a veritable "allergy" to common fractions, preferring the most extensive and round about procedure to convert all data to decimals and carry on all operations with them rather than use a common denominator or invert a divisor.

The second need is a foundation in algebra, with particular emphasis on formulas. An ability to use the quadratic formula is preferred to solution by factoring, since only text-book problems are likely to be factorable; those occuring in actual work situations are never so conveniently designed. The toolmaker is not ordinarily concerned with cubic or higher degree equations. Problems involving more advanced mathematics of any sort are calculated by the engineering staff and the results placed on the blueprint before the toolmaker receives it.

A third need is for a thorough grasp of plane geometry. Here, the emphasis is on application rather than proof. If the worker knows that the angles of a triangle add up to 180°, he can always use two given angles to find the third even though he can't offer formal proof that their sum is a straight angle. He need not know even *one* of the more than 200 proofs of the theorem of Pythagoras, providing he can use that theorem for solving problems. Too much importance cannot be attached to acquiring a detailed grasp of geometry. Many problems come to the machinist through the medium of blue prints, and although trigonometry, algebra, and arithmetic may be employed in their solution, the analysis usually starts with geometry—constructing triangles, connecting centers of circles, points of tangency, etc.

Although not regarded as a separate branch of mathematical science, I think we should list logarithms as the fourth basic need of our tool-maker. The need to perform all computation rapidly yet accurately makes it the ideal tool for all computation to which it is applicable. This most certainly includes all triangulation problems, and it has been found that time is saved and the desirable habit of using logarithms whenever possible is fostered by avoiding tables of natural trigonometric functions completely and employing tables of logarithms of trigonometric functions right from the start. I am frequently asked why we don't teach the slide rule instead. The answer is that we do in certain trades. But the slide rule is too inaccurate for work

which may be measured to an accuracy of 1/10,000 of an inch or even less. Five place log tables cover this need excellently and are to be found in any good handbook for the machinist.

The fifth need is trigonometry with most of the theory left out. Most tool-maker's problems can be solved by means of right triangulation. Knowing the six functions and enough algebra to use them is adequate for most work. For the rare problem where oblique triangles must be solved, several methods might be used. Many texts for industrial mathematics offer the cosine law for all situations where the sine law is inapplicable. However, if we are going to insist on regular use of logarithms and logs of trig functions, the tangent law and half angle formula should be substituted for the cosine law. As an alternative, particularly in some of the other trades where oblique, triangles are nearly unknown, it may save time to point out the oblique triangle formulas in the handbook and teach direct substitution in the formula. This may be mathematical heresy, but it meets a need, and does it efficiently. And after all, technical mathematics need not be all inclusive of a specific area or mathematical topic; it need cover only specially selected items that meet specific vocational needs. This is in keeping with our premise that mathematics in the technical field is a means to an end rather than an end itself.

A sixth need might be called solution of compound angles. By this we mean rotating a calculated angle about two or three different axes, depending on the construction of the machine holding it, in order to obtain a given dihedral angle. For such work, some understanding of solid and descriptive geometry is needed, although only selected portions of these subjects need be presented.

Many times in the past we have been asked about the text and problem material used in our mathematics classes. A brochure has been prepared which contains samples of a few of the problems that we have taken from the shop for use in classes. With each is an explanatory note telling the source, part, or work situation from which the problem evolved.

To clarify even further the connection between the job and the resulting problem, the student may be supplied with a blueprint of a part from the Chrysler power steering unit. Here is indicated with red pencil a problem that occurred in the tool room where a gage for checking the serrations had to be set up. The taper and angle of cut make this a very interesting shop type problem. This problem was solved by one of our former apprentices as part of his work in making and setting up the special gage.

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Pressurized oil can is a spray gun affair that blows a fine mist of light-weight machine oil on tools, toys and sporting equipment to prevent rusting.

# THE PLACE OF SCIENTIFIC RESEARCH IN LIBERAL ARTS COLLEGES

JOHN R. SAMPEY
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Historically liberal arts colleges in the United States have displayed little interest in scientific research. They have been engaged primarily in laying broad foundations of general culture in the arts, the humanities, the social sciences and the natural and physical sciences. They have been far more concerned with teaching students to build a satisfying and enduring philosophy of life than in how to make a living in our highly competitive social order. The teachers in liberal arts colleges have been given little time or incentive to make contributions to creative scholarship in any field, but they have left such exacting duties to their more disciplined colleagues in the universities.

A number of forces, however, have been at work during the last two decades to change this traditional pattern of the liberal arts college. Industry and the graduate schools of the universites have been demanding more professional training of college undergraduates. Societies like the American Chemical Society have erected strict professional requirements which colleges must satisfy to be placed upon their accredited list.

The liberal arts teacher is being offered more and more inducements to give more and more of his time to research. Fifteen years ago Dr. E. Emmet Reid, Emeritus Professor of the Johns Hopkins University, launched a program to promote scientific research in the South.[1] The Carnegie Foundation for the Advancement of Teaching has just concluded a five year experiment at a cost of more than a million dollars to stimulate creative scholarship in colleges and universities in the same section.[2] And finally, the comprehensive study of Knapp and Goodrich[3] on the origins of American scientists has shown that liberal arts colleges lead all other types of institutions in the training of the nation's scientists. This latter fact has resulted in greatly increased allotments of funds for scientific research to the smaller colleges—a recent list of awards by the National Science Foundation included grants to seventeen liberal arts colleges.

After this brief sketch of some of the forces at work today to change the traditional pattern of the liberal arts college it is not surprising to find that those teaching science in these institutions are moving in the direction of increased interest and productivity in research.

[1] Sampey, J. R., *Jour. Chem. Education*, 28, 32 (1951).

[2] Lowry, H. and Taesch, W., *Research, Creative Activity and Teaching*, Carnegie Foundation for the Advancement of Teaching, N. Y. C., 1953.

[3] Knapp, R. H. and Goodrich, H. B., *Origins of American Scientists*, University of Chicago Press, 1952.

The two journals which have the most comprehensive coverage of the world's literature in the chemical and biological sciences are *Chemical Abstracts and Biological Abstracts*. A check on the publications from liberal arts colleges in these two abstract journals will give a significant picture of scientific research in these institutions.

A survey of *Chemial Abstracts* for 1953 shows that 59 liberal arts colleges contributed 143 articles during the year to this key to the world's chemical literature. The *College Blue Book*[4] has been used to determine the liberal arts status of the colleges. Institutions which award the Ph.D. degree, or which have professional schools of agriculture, dentistry, medicine, pharmacy or other applied sicences are not classed as liberal arts.

The showing of liberal arts colleges in *Chemical Abstracts* for 1952 was 51 colleges contributing 98 articles.[5] This increase in published research of one-third within twelve months is significant of the change taking place in liberal arts colleges. A closer study of the data indicates that a few colleges are launched upon a continuing program of research while the majority continue to remain indifferent to the new development.

Almost fifty per cent of the material in *Chemical Abstracts* for 1952 from liberal arts colleges was contributed by eight colleges (Amherst, Brooklyn, Carson-Newman, Furman, Mount Holyoke, Oberlin, Richmond and Wesleyan), and 54 of the 143 articles of 1953 originated in just six colleges (Amherst, Antioch, Brooklyn, Bryn Mawr, Mount Holyoke and Trinity (Texas)). Moreover, ten liberal arts colleges published six or more articles during the two year period to account for the impressive total of 109 publications (Amherst, Antioch, Brooklyn, Bryn Mawr, Carson-Newman, Furman, Mount Holyoke, Oberlin, Pomona and Reed).

On the other hand, a majority of the liberal arts colleges demonstrated little interest in scientific research, for 34 of the 51 listed in *CA* for 1952 contributed only one article, and 31 of those in 1953 had one article only. And 30 of the 59 colleges in the 1953 *CA* made no contribution in 1952.

An examination of *Biological Abstracts* for 1951 discloses a similar picture of intensive interest in research by a few liberal arts colleges but an apathetic attitude by many.[6] Forty-seven liberal arts colleges contributed 103 articles to the 1951 *BA*. Fifty-one of these publications originated in just five institutions (Amherst, Butler, Florida Southern, Mount Holyoke and William and Mary). In contrast, 60% of the 51 colleges had only one article abstracted in the 1951 *BA*.

[4] Hurt, H. W. and Abbot, M. E., *College Blue Book*, 7th Edition, C. E. Burckel, Yonkers-on-Hudson, N. Y., 1953.

[5] Sampey, J. R., *Jour. Chem. Education*, 31, 14 (1954).

[6] Sampey, J. R., *Jour. Higher Education*, 24, 433 (1953).

# RECREATIONAL MATHEMATICS AS IT MAY BE USED WITH SECONDARY SCHOOL PUPILS

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A number of teachers have asked, "Just what is recreational mathematics and how can it be used in teaching mathematics to secondary school pupils?" The presentation that follows is an attempt to answer this question.

## RECREATIONAL MATHEMATICS

Recreational mathematics may be defined as mathematical materials that can be treated in a recreational and entertaining manner.

There is nothing new about recreational mathematics. Plato and Socrates taught geometry to their pupils so that they might enjoy more the pleasure of reasoning. The followers of Pathagoras experimented with phases of mathematics largely for their own pleasure. A book entitled *Pleasure With Profit*, by William Leyborn, published in 1694 "to recreate ingenious spirit," may be found in the Main Library of the University of California, Berkeley. This book treats such items as building a thermometer, chess moves, algebraic problems, cryptology, and astronomy as recreational mathematics.

Modern authors of recreational mathematics books, with some exceptions, are similarly concerned with elements of mathematics that are beyond the interests and abilities of most secondary school pupils. The recreational mathematics with which we wish to be concerned includes such materials as may be understood and enjoyed by a majority of secondary school pupils. Thus, much of the available material must be revised in terms of the interests and abilities of the children that make up the secondary school mathematics classes.

The use of recreational mathematics in the classroom is not a "cure all" for the "ills" that may be associated with the mathematics subjects. However, in the hands of a competent teacher it can serve as an instrument to favorably change the attitude of children towards the mathematics subjects. It may further serve as an instrument with which to teach mathematics to children.

## EXAMPLES OF RECREATIONAL MATHEMATICS ITEMS

Included in the recreational mathematics interest areas that can be used successfully with secondary school pupils are recreational-type quizzes, number oddities, tricks and games, and puzzles. These interest areas will be briefly illustrated and discussed on this and the following pages.

*The Recreational-Type Quiz.* The recreational-type quiz consists of

quiz items of a recreational nature that have special appeal to secondary school pupils. Such quizzes may be made up of multiple-choice items, matching items, or short answer items. The quizzes may be directed at specific subject areas such as arithmetic, algebra, or geometry. Phases of subject matter that lend themselves to the recreational-type quiz include definitions of terms, units of measure, fundamentals of a subject area, and tricky problems.

The quizzes can be directed by a teacher or a pupil to a panel group selected from a class, or offered to a class in a Dr. I. Q. fashion, or they may be given to members of a class at their seats from duplicated sheets as a recreational test and followed by discussion.

Such quizzes have proved very effective when used to "settle down" a class that has come into a classroom "high" and/or "talkative" as a result of a stimulating assembly program, football rally, rainy day, etc. A research function may also be provided by challenging pupils to make up quizzes of this type as special class projects. The tests should prove not only recreational, but serve as an excellent teaching device for adding the "general education aspect" to the mathematics subjects.

The first example of recreational-type quizzes is designed for general mathematics pupils, the second is designed for geometry pupils.

*Examples of Recreational-Type Quizzes*:

TEST YOURSELF ON MATHEMATICAL TERMS

Here is a chance 4 U 2 C how well you know some of the mathematical terms that are used in everyday conversation. This is a multiple-choice type quiz. Select the item from the list following each question that you feel is the correct answer and indicate it in the space provided at the left. Time is limited to fifteen minutes.

_____ 1. If Tom runs the "440" in a track meet, what part of a mile does he run? (a). 3/4 mile. (b). 1 mile. (c). 1/4 mile. (d). 1/2 mile. (e). Answer is not listed.

_____ 2. The short ton is a measure of weight in common use in the United States and Canada; the long ton, or shipping ton is used throughout the world to measure cargo aborad ships. How large is a long ton? (a). 2400 pounds. (b). 2000 pounds. (c). 2420 pounds. (d). 2240 pounds. (c). Answer is not listed.

_____ 3. Paper is sold by the quire and by the ream. How many sheets of papaper in a quire? (a). 500. (b). 24. (c). 144. (d). 20. (e). Answer is not listed.

_____ 4. In Shakesphere's "The Tempest" there is a line: "Full fathoms five thy father lies." How deep is a fathom? (a). 18 inches. (b). 3 feet. (c). 3 yards. (d). 10 feet. (e). Answer is not listed.

_____ 5. The fifteenth verse of the seventh chapter of Genesis gives the dimensions of Noah's Ark. It reads, "The length of the ark shall be 300 cubits, the breadth of it 50 cubits, and height of it 30 cubits." How long is a cubit? (a). One foot. (b). 16½ feet. (c). 18 inches. (d). 36 inches. (e). Answer is not listed.

_____ 6. Horse traders still refer to the height of a horse as being a certain number of hands high. For example, a horse that is 17 hands high would be quite a large horse. What is the height measured by 1 hand? (a). 4 inches. (b). 5 inches. (c). 3 inches. (d). 7 inches. (e). Answer is not listed.

_____ 7. A boss told one of his employees that he could have a vacation of a fortnight each year. How long a time is a fortnight? (a). 4 days. (b). Two weeks. (c). 20 days. (d). One month. (e). Answer is not listed.

_____ 8. There are two kinds of miles in common use; the statute mile, or land mile, such as might be used to measure the distance traveled in an automobile and the nautical mile, or navigator's mile, such as might be used to measure the distance covered by a ship or airplane. How far is a nautical mile? (a). 5,280 ft. (b). 8,060 ft. (c). 2,580 ft. (d). 6,080 ft. (e). Answer is not listed.

_____ 9. A carat is a unit used to express the fineness of gold in pieces of jewelry. For example, you might find the figures 16K stamped on the inside of a gold ring. This would mean 16 carat gold alloy. How pure is 16 carat gold? (a). 1/2. (b). 100%. (c). 2/3. (d). 3/4. (e). Answer is not listed.

_____ 10. Abe Lincoln once said, "Four score and seven years ago. . . . " How long is four score and seven years? (a). 27 years. (b). 21 years. (c). 47 years. (d). 87 years. (e). Answer is not listed.

Scores: 0–2, Frigid; 3–4, Cold; 5–6, Moderate; 7–8, Hot; 9–10, Boiling.

### Test Yourself on Geometrical Terms

Here is a chance 4 U 2 test your skill with geometrical terms. A geometrical term will answer each of the following questions as a pun. In case you've forgotten, a list of terms may be found at the bottom of the page. Time is limited to ten minutes.

1. Where do people go for committing crimes? Answer: _____
2. What is a phonograph record that isn't there? Answer: _____
3. What does one old farmer often say to another? Answer: _____
4. What are boats that cross the ocean called? Answer: _____
5. What do gentlemen go to the beach for? Answer: _____
6. Name a food that is a dessert. Answer: _____
7. What do little acorns say when they grow up? Answer: _____
8. What did the forgetful professor say about the letter he had carried in his pocket for a week before mailing? Answer: _____
9. What should a person do when it rains? Answer: _____
10. What could you called a dead parrot? Answer: _____

*Some Geometrical Terms*

| | | | |
|---|---|---|---|
| Secant | Pi | Geometry | Chord |
| Decagon | Prism | Sector | Loci |
| Tangent | Hexagon | Postulate | Perimeter |
| Hypotenuse | Polygon | Coincide | Transversal |

*Scores:*

| | |
|---|---|
| 10 Atomic | 4–5 Warm |
| 8–9 Volcanic | 2–3 Dying |
| 6–7 Hot | 0–1 "Plum" dead |

*Number Oddities.* Number oddities consist of such number relationships as might appear to be unusual or hold special interest. Such relationships includes sums and/or products that have an unusual digit sequence, magic squares, and short cuts of multiplication. These items may prove of special assistance in teaching phases of addition and multiplication of whole numbers.

The interesting number relationships should provide a device for use with remedial groups. The sequence of digits provided by the indicated operations makes errors very obvious to pupils when used along with drill exercises. The unusualness of the relationships hold a fascination to fast and slow pupils alike.

There are a number of patterns that can be used in the development of magic squares. To discover the patterns of numbers used to make up magic squares and to use such patterns to make other magic squares takes ingenuity and skill. The resulting order of numbers provides a handy device for teaching horizontal additional and two-digit number addition without the use of pencil and paper.

Besides serving to amuse the pupils, short cuts of multiplication are a useful device for developing new skills in arithmetic. Most children can follow the directions for the short cuts and find delight in their acquired ability to multiply certain pairs of two-digit numbers. These short cuts can be further used to give a "real" meaning to the special products of algebra.

The first example of number oddities presents some interesting number relationships, the second presents a number of magic squares, and the third example presents a number of special products.

*Examples of Number Oddities:*

INTERESTING NUMBER RELATIONSHIPS

If you have not been previously introduced to certain number relationships, the results of operations with certain numbers will surprise you. For example:

$$\begin{aligned}
1\times 9 \text{ plus } 2 &= 11\\
12\times 9 \text{ plus } 3 &= 111\\
123\times 9 \text{ plus } 4 &= 1{,}111\\
1{,}234\times 9 \text{ plus } 5 &= 11{,}111\\
12{,}345\times 9 \text{ plus } 6 &= 111{,}111\\
123{,}456\times 9 \text{ plus } 7 &= 1{,}111{,}111\\
1{,}234{,}567\times 9 \text{ plus } 8 &= 11{,}111{,}111\\
12{,}345{,}678\times 9 \text{ plus } 9 &= 111{,}111{,}111\\
123{,}456{,}789\times 9 \text{ plus } 10 &= 1{,}111{,}111{,}111
\end{aligned}$$

Following are additional examples of interesting number relationships to be worked out:

1.
$1\times1=$
$11\times11=$
$111\times111=$
$1{,}111\times1{,}111=$
$11{,}111\times11{,}111=$
$111{,}111\times111{,}111=$
$1{,}111{,}111\times1{,}111{,}111=$
$11{,}111{,}111\times11{,}111{,}111=$
$111{,}111{,}111\times111{,}111{,}111=$

2.
$9\times9$ plus $7=$
$9\times98$ plus $6=$
$9\times987$ plus $5=$
$9\times9{,}876$ plus $4=$
$9\times98{,}765$ plus $3=$
$9\times987{,}654$ plus $2=$
$9\times9{,}876{,}543$ plus $1=$
$9\times98{,}765{,}432$ plus $0=$
$9\times987{,}654{,}321$ less $1=$

3.
$12{,}345{,}679\times\ 9=$
$12{,}345{,}679\times18=$
$12{,}345{,}679\times27=$
$12{,}345{,}679\times36=$
$12{,}345{,}679\times45=$
$12{,}345{,}679\times54=$
$12{,}345{,}679\times63=$
$12{,}345{,}679\times72=$
$12{,}345{,}679\times81=$
$12{,}345{,}679\times90$ plus $1=$

4.
$33\times3{,}367=$
$66\times3{,}367=$
$99\times3{,}367=$
$132\times3{,}367=$
$165\times3{,}367=$
$198\times3{,}367=$
$231\times3{,}367=$
$264\times3{,}367=$
$297\times3{,}367=$

$37{,}037\times\ 3=$
$37{,}037\times\ 6=$
$37{,}037\times\ 9=$
$37{,}037\times12=$
$37{,}037\times15=$
$37{,}037\times18=$
$37{,}037\times21=$
$37{,}037\times24=$
$37{,}037\times27=$

6.
$1\times8$ plus $1=$
$12\times8$ plus $2=$
$123\times8$ plus $3=$
$1{,}234\times8$ plus $4=$
$12{,}345\times8$ plus $5=$
$123{,}456\times8$ plus $6=$
$1{,}234{,}567\times8$ plus $7=$
$12{,}345{,}678\times8$ plus $8=$
$123{,}456{,}789\times8$ plus $9=$

7.
$9\times9=$
$99\times99=$
$999\times999=$
$9{,}999\times9{,}999=$
$99{,}999\times99{,}999=$

8.
$999{,}999\times2=$
$999{,}999\times3=$
$999{,}999\times4=$
$999{,}999\times5=$
$999{,}999\times6=$
$999{,}999\times7=$
$999{,}999\times8=$
$999{,}999\times9=$

## Magic Squares

Following are a number of magic squares. The patterns for these squares can be determined by following consecutive numbers. Once the patterns have been established, squares can be made from sequences of consecutive numbers other than those starting with one.

| | | | | |
|---|---|---|---|---|
| 16 | 2 | 3 | 13 | 34 |
| 5 | 11 | 10 | 8 | 34 |
| 9 | 7 | 6 | 12 | 34 |
| 4 | 14 | 15 | 1 | 34 |
| 34 | 34 | 34 | 34 | 34 |

| | | | | | |
|---|---|---|---|---|---|
| 23 | 12 | 1 | 20 | 9 | 65 |
| 4 | 16 | 7 | 21 | 15 | 65 |
| 10 | 24 | 13 | 2 | 16 | 65 |
| 11 | 5 | 19 | 8 | 22 | 65 |
| 17 | 6 | 25 | 14 | 3 | 65 |
| 65 | 65 | 65 | 65 | 65 | 65 |

| | | | | | |
|---|---|---|---|---|---|
| 17 | 24 | 1 | 8 | 15 | 65 |
| 23 | 5 | 7 | 14 | 16 | 65 |
| 4 | 6 | 13 | 20 | 22 | 65 |
| 10 | 12 | 19 | 21 | 3 | 65 |
| 11 | 18 | 25 | 2 | 9 | 65 |
| 65 | 65 | 65 | 65 | 65 | 65 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 46 | 31 | 16 | 1 | 42 | 27 | 12 | 175 |
| 5 | 39 | 24 | 9 | 43 | 35 | 20 | 175 |
| 13 | 47 | 32 | 17 | 2 | 36 | 48 | 175 |
| 21 | 6 | 40 | 25 | 10 | 44 | 29 | 175 |
| 22 | 14 | 38 | 33 | 18 | 3 | 37 | 175 |
| 30 | 15 | 7 | 41 | 26 | 11 | 45 | 175 |
| 38 | 23 | 8 | 49 | 34 | 19 | 4 | 175 |
| 175 | 175 | 175 | 175 | 175 | 175 | 175 | 175 |

A magic square?????????

| | | | | |
|---|---|---|---|---|
| 24 | 31 | 8 | 15 | 22 |
| 30 | 12 | 14 | 21 | 23 |
| 11 | 13 | 20 | 27 | 29 |
| 17 | 19 | 26 | 28 | 10 |
| 18 | 25 | 32 | 9 | 16 |

## Special Products

I. *To multiply two numbers between 10 and 20.* To the whole of one number add the units digit of the other and annex a zero; to this number add the product of the two units digits.
*Example:* Multiply 19×16. 19 plus 6 is 25; annex a 0, making it 250; 6×9 is 54; add 250 and 54, obtaining 304. Answer is 304.
*Example:* Multiply 17×14. 14 plus 7 is 21; annex a 0, making it 210; 4×6 is 28; add 210 and 28, obtaining 238. Answer is 238.

II. *To find the product of any two numbers with the same tens digits.* Add the whole of one number to the units of the other and multiply by the tens digits, annex a 0; to this number add the product of the two units digits.
*Example:* Multiply 35×37. 35 plus 7 is 42; 3×42 is 126; annex a 0, making it 1260; 5×7 is 35; add 1260 and 35, making 1,295. Answer is 1,295.
*Example:* Multiply 83×85. 83 plus 5 is 88; 8×88 is 704; annex a 0, making it 7040; 3×5 is 15; add 7040 and 15 making 7,055. Answer is 7,055.

III. *To find the product of a pair of numbers whose tens digits are the same and whose units digits total 10.* This product is equal to a number whose first part is the product of the tens digit and the next consecutive digit, and whose second part of two digits is the product of the two units digits.
*Example:* 83×87 is found as follows: 8×9 is 72; 3×7 is 21. The answer is 7,221.
*Example:* 91×99 is found as follows: 9×10 is 90; 9×1 is 09. The answer is 9,009.

IV. *To find the product of a pair of numbers whose difference above and below a multiple of 10 is the same.* Multiply the tens digit by itself and annex two zeros; multiply the difference above and below the multiple of 10 by itself; subtract the second result from the first. The difference is the desired result.
*Example:* 81×79 is found as follows: 8 is the multiple of 10; 8×8 is 64. Annex two zeros; 6400. The difference above and below 80 is 1; 1×1 is 1. Subtract 1 from 6400; 6400−1 is 6,399. The answer is 6,399.

*Example:* 42×38 is found as follows: 4 is the multiple of 10; 4×4 is 16. Annex two zeros; 1600. The difference above and below 40 is 2; 2×2 is 4. Subtract 4 from 1600; 1600−4 is 1,596. The answer is 1,596.

*Problems for Special Products*

| I. | II. | III. | IV. |
|---|---|---|---|
| 11×15 | 33×35 | 94×96 | 43×37 |
| 17×15 | 56×58 | 92×98 | 71×69 |
| 19×12 | 52×59 | 45×45 | 25×15 |
| 15×18 | 52×57 | 71×79 | 54×46 |
| 16×12 | 82×86 | 82×88 | 84×76 |

*Tricks and Games.* Mathematical tricks are "attention getters." They can also be used to help establish some fundamental concepts of arithmetic by illustrating obvious and ridiculous errors. Tricks may also be used to illustrate to pupils how statements may be easily misinterpreted and to indicate the need for carefully reading written problems. They should offer special assistance in "selling" the mathematics subjects to children.

Mathematical games provide an excellent device to turn "drill work" into play, especially at the 7th-, 8th-, and 9th-grade levels. There are many games that can be used successfully in the mathematics classroom.

A number of mathematical tricks and a classroom game are presented in the following example of tricks and games.

*Example of Tricks and Games:*

TRICKS AND GAMES

*Number Trick.* To tell a person's age and house number have the person do as follows: Write down the number of his house. Double it. Add 5. Multiply by 50. Add his age. Add the number of days in a year (365). Subtract 615. Have him give you his result. If his computations have been correct the number of his house will appear in front of his age.

*Riddle.* Can you solve the following riddle: If from six you take nine, if from nine you take ten, and if from forty you take fifty, six will remain. (Hint: Use Roman numerals.)

*Trick with Pennies.* I have 9 pennies. Can you arrange them so that I will have three and one-half dozen?

*Tricky Question.* How can thirteen potatoes be divided equally among eight dinner guests without being cut?

*Trick in Division.* Can you take half of twelve and get seven? (Hint: If you should run into difficulty, try the Roman numeral notation for twelve.)

*Accomplishing the Impossible.* Here is a trick that may prove dangerous . . . for you, depending upon the good nature of your audience. Tear a small hole in a sheet of paper; then after remarking of your ability for accomplishing the impossible, announce that you can push a large object through the hole without tearing the paper. Just be sure that the hole in the paper is large enough for the pencil that you extend through the hole to push the object.

*Trick of Digit Addition.* Below are three sets of digits . . . three fives, three ones, and three nines, a total of nine digits. They provide an interesting problem. The object is to cross out six of the digits and leave three that when added together have a sum of twenty.

| | | |
|---|---|---|
| 555 | 111 | 999 |

*A Game of Football for the Classroom.* Children in a class may be divided into two or more teams depending upon the number in the class. This may be done according to rows of seats. Each team is given a name. One team may play against another, or three or more teams may participate at once with the winner being the team scoring the most points. A football diagram is drawn on the chalkboard. The positions of the teams will be indicated on this diagram. Scores may be kept on a scoreboard drawn alongside.

A list of problems and/or questions, all on separate slips, should be prepared such that they can be drawn from a box by the team that "has the ball." Correct responses will advance the ball 5, 10, 15 or more yards as indicated on the slip. The yardage advanced should be in proportion to the difficulty of the problem or question. Each pupil takes his turn at "carrying the ball."

If a pupil "fumbles" by giving an incorrect answer, a member of the other team(s) may "recover" by giving the correct answer. The team "recovering" will proceed to carry the ball toward the opposite goal, until scoring points, fumbling, or losing the ball on downs. Failure of an opposing team to "recover a fumble" scores a "down" against the team in possession of the ball.

Teams get a chance to kick for extra points, try for field goals, etc. The game is terminated at the end of a certain period of time, say 30 minutes. The team with the highest score wins the game.

*Puzzles.* There are a great many types of mathematical puzzles that lend themselves to classroom use. Included among such puzzles are written puzzles, number puzzles, maze puzzles, cut-up puzzles, mathegrams, line puzzles, and cross-number puzzles. Perhaps the most useful of the puzzles, as a teaching device, is the cross-number puzzle.

Before children can enjoy solving cross-number puzzles it is usually necessary to teach them the method of solving such puzzles. Once this has been accomplished, cross-number puzzles can be developed for classroom use for any particular unit of work in mathematics. Such puzzles provide individual challenge for pupils and serve as an excellent remedial device by which children can discover their own errors. The puzzles serve to provide a "painless" way to review mathematics materials, that can be effective both as a classroom lesson and as a home or study period assignment. Cross-number puzzles can readily be developed on units of arithmetic, algebra, and geometry.

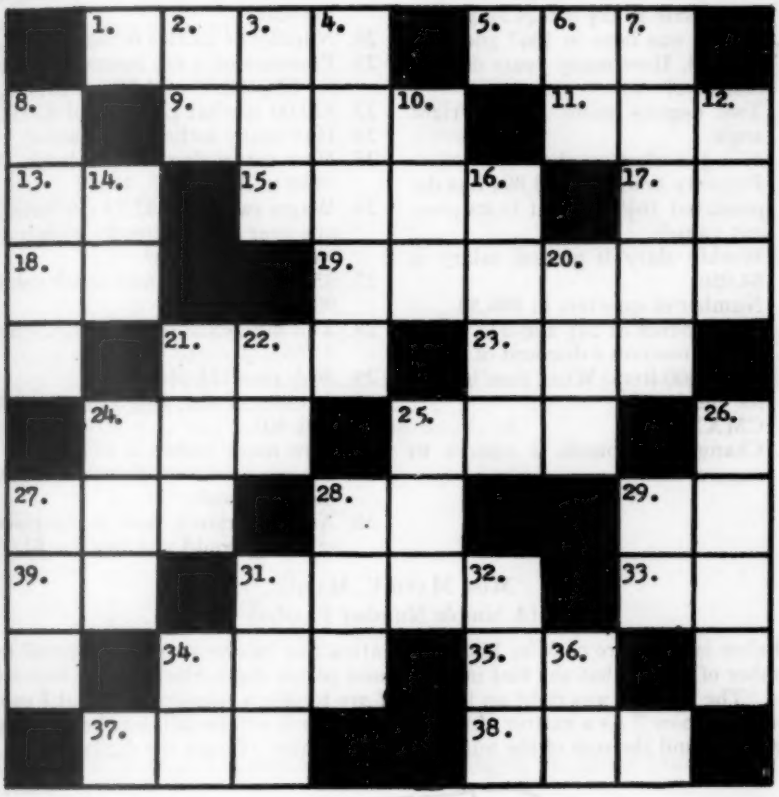
Other types of puzzles can be similarly developed for a wide range of interests and abilities. Number puzzles and cut-up puzzles should assist in developing patience and accuracy; written puzzles and mathegrams should assist in developing elements of reasoning. Working with these various puzzles should help pupils to realize the need for a "systematic method" of "attacking" problems and provide teachers with a "crutch" for teaching pupils to solve written problems.

A cross-number puzzles and a simple number puzzle are presented as examples of puzzles.

*Examples of Puzzles:*

### Cross-Number Puzzle

Below is a cross-number puzzle. It is solved like a cross-word puzzle, except that numbers are used in the puzzle rather than words. See if you can solve the puzzle.




*Horizontal*

1. Round off $9,352.67 to the nearest dollar.
5. The perimeter of a 52.75-inch square.
8. How many months in one-fourth a year?
9. The sum of $3,887.23, $1,769.45, and $2,676.32.
11. How long ago was 1653?
13. In what century was 1776?
15. One more than ten times the square of twenty-five.
17. What would you pay for 13 oranges at 48¢ a dozen?
18. 25% of 96.
19. The product of 4,027 and 126.
21. Area of a circle whose radius is 7 inches.

*Vertical*

1. Two-thirds of what number is 6?
2. How many feet in $12\frac{1}{3}$ yards?
3. The quotient of 14,472 and 27.
4. Round off 33,254.498 to the nearest integer.
5. The number multiplied by twice itself is 8.
6. $3\frac{1}{2}$ plus $4\frac{1}{4}$ plus $5\frac{5}{12}$.
7. Principal at 5% rate necessary to provide an annual interest of $525.00.
8. How many thousands in $3\frac{1}{4}$ millions?
10. Area of a triangle whose altitude is 25 inches and whose base is 28 inches.
12. Total number of days in April, May, June, and July.

23. Interest on \$10,000 at $3\frac{1}{2}\%$ for two years.
24. $112\frac{1}{2}\%$ of 96.
25. 500 increased by 11%.
27. Perimeter of a regular hexagon whose side is $25\frac{1}{3}$ inches long.
28. A man was born in 1867 and died in 1948. How many years did the man live?
29. Two degrees more than a right angle.
30. 27 is $\frac{3}{4}$ of what number?
31. Property bought at \$3,894 has depreciated $16\frac{1}{2}\%$. What is its present value?
33. Weekly slary if annual salary is \$4,056.
34. Number of quarters in \$86.50.
35. The product of $21\frac{1}{4}$ and $3\frac{1}{3}$.
36. A man receives a discount of $13\frac{1}{2}\%$ on a \$400 item. What does he pay for the item?
37. CMXXVI.
38. Change 44 pounds 2 ounces to ounces.

14. Perimeter of a rectangle whose width is $26\frac{3}{4}$ in. and whose length is $15\frac{1}{2}$ in.
16. At 14.2 miles per gallon, how far will a car travel on 126 gallons of gasoline?
20. Number of nickles to make \$20.25.
21. Premium on a fire insurance policy for \$24,000.00 at 4.25 per \$1,000.
22. \$29.00 is what per cent of \$50.00?
24. How many inches in $4\frac{1}{3}$ yards?
25. How many days from March 19, 1950 to August 15, 1951?
26. Wages earned at \$2.75 per hour in one year if a man works 40 hours a week for 48 weeks?
27. 45° below zero is how much colder 90° above zero?
28. The difference between 1,327 and 2,153.
29. $36\frac{5}{13}$ plus $17\frac{1}{3}$ plus $43\frac{1}{4}$.
31. Average of 471; 334; 358; 221; 289; and 403.
32. How many inches in $15\frac{3}{4}$ yards?
34. Freezing point on Fahrenheit thermometer scale.
36. At 15¢ a dozen, how many pieces of candy could you buy for \$1.00?

## Miss Math E. Matics
(A Simple Number Puzzler)

Below is a picture of Miss Math E. Matics. She has been trying to recall the number of pupils that she had in her second period class. She was just heard to say, "The number was right on the tip of my tongue a moment ago, but I can't think of it now." As a matter of fact, the number is written all over her face. See if you can find the sum of the numbers written there. (Count the digits only.)

## ANSWERS

*Test Yourself on Mathematical Terms:*

| | | | | |
|---|---|---|---|---|
| 1. c | 3. b | 5. c | 7. b | 9. c |
| 2. d | 4. e | 6. a | 8. d | 10. d |

*Test Yourself on Geometrical Terms:*

1. To *prism*
2. A *decagon*
3. *Loci.*
4. *Transversals.*
5. To become *tangents.*
6. *Pi.*
7. *Geometry.*
8. I'll *postulate.*
9. *Coincide.*
10. A *polygon.*

*Tricks and Games*

Riddle: SIX IX XL
IX X L

S I X

Trick with pennies: Three and six (six is half dozen).
Tricky question: Mash them.
Trick in division: ~~XII~~; divide the Roman number 12 into two equal parts between top and bottom.
Trick in addition: Leave 11 and 9; their sum is 20.

*Cross-Number Puzzle:*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| X | 9 | 3 | 5 | 3 | X | 2 | 1 | 1 | X |
| 3 | X | 8 | 3 | 3 | 3 | X | 3 | 0 | 1 |
| 1 | 8 | X | 6 | 2 | 5 | 1 | X | 5 | 2 |
| 2 | 4 | X | X | 5 | 0 | 7 | 4 | 0 | 2 |
| 5 | X | 1 | 5 | 4 | X | 7 | 0 | 0 | X |
| X | 1 | 0 | 8 | X | 5 | 5 | 5 | X | 5 |
| 1 | 5 | 2 | X | 8 | 1 | X | X | 9 | 2 |
| 3 | 6 | X | 3 | 2 | 4 | 5 | X | 7 | 8 |
| 5 | X | 3 | 4 | 6 | X | 6 | 8 | X | 0 |
| X | 9 | 2 | 6 | X | X | 7 | 0 | 6 | X |

*Miss Math E. Matics:* The sum of the digits making up the face of Miss Math E. Matics is 50.

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## U. S. EXPERT TO HEAD UNESCO PROGRAM

Dr. Luther H. Evans, Director General of Unesco, has announced the Appointment of Dr. Ellsworth S. Obourn of the John Burroughs School, Clayton, Missouri, in the U.S.A. to take charge of Unesco's program for the study of science education and the improvement of science teaching in the Member States of Unesco. Dr. Obourn has already served as technical expert and advisor to the Ministry of Education at Bangkok in Thailand in 1952 and 1953 on a Unesco project being carried out under the UN expanded program of Technical Assistance.

Since one of the primary needs of the underdeveloped countries is the increased use of science in agriculture and industry, there is a universal demand for the expansion of science instruction in the schools. In many countries it has been nonexistent, except for university training, and Unesco's first emphasis is on the improvement of science in the primary schools, especially in those countries where 99% of the children do not go beyond fifth or sixth grade. The most important element of Unesco's campaign is the introduction of the laboratory method of instruction and thus of training in the habit of experiment and of scientific thought.

# ANIMAL EXPERIMENTATION AND HUMAN HEART DISEASE[1]

LOUIS N. KATZ[2]
*Michael Reese Hospital, Chicago 16, Ill.*

Mr. Chairman, ladies and gentlemen. I know all of you are getting hungry. Far be it for me to make a long appeal to the heart when you feel the call of the stomach, after having listened to an appeal to the mind. It is a privilege to address this section of the Central Association of Science and Mathematics Teachers, because as teachers it is your task to inform; and to inform, you must know. It is particularly intriguing to talk to science and mathematics teachers because the physics and mathematics of hydraulics is most difficult to understand and to present. And of all phases of hydraulics, that which deals with elastic tubes is the most difficult, especially when it concerns branching elastic tubes. That is exactly the physics of the heart and circulation. I shall not indulge, for your edification, in any dissertations of the the laws that govern the flow of blood in the arteries, veins and capillaries, nor of the laws that make the valves move and create the sounds and murmurs of the heart.

I want to deal with the subject clinically because it *is* true that as many people die of heart disease, as all of other diseases combined. Today there are ten million people in the United States who have one or another form of heart disease; some are psychogenic. When we talk about heart disease, we are in reality talking of some twenty odd diseases. But only three are important numerically. Rheumatic fever is an infection of unknown origin, somehow associated with a strain of streptococcus that affects the heart and its valves. It is far more important in young people from five to eighteen years than any other infectious disease. Teachers should know this. High blood pressure is the second important form. It affects the middle-aged population, and the older population—those in whom society has invested a great deal of know-how. This disease foreshortens existence so that society does not get gack all the wisdom expected of people as they grow older. Closely associated with high blood pressure is arteriosclerosis, or hardening of the arteries, which reaches the headlines in the newspapers as people succumb to its more acute devastating reactions. These are the big three of heart diseases—in fact, of all forms of disease.

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[1] Presented at the Conservation Group of the Central Association of Science and Mathematics Teachers at Chicago, November 28, 1953.

[2] Director, Cardiovascular Department, Medical Research Institute, Michael Reese Hospital; Professorial Lecturer, Department of Physiology, University of Chicago; Past President, American Heart Association; President, Illinois Society for Medical Research.

Today most diabetics die of the associated hardening of the arteries rather than from the diabetes itself. One can point to the experiments carried out on rabbits and dogs, particularly at the University of Toronto, where the hormone insulin was first isolated by a group of physicians as the cause of this changing mortality pattern, a change associated with a longer life expectancy. Incidentally, other hormones manufactured by the pituitary and the adrenal glands—like ACTH, cortisone, hydrocortisone, desoxycorticosterone—and the newest hormone just announced a few months ago—have changed the complexity of all diseases including the heart diseases. The other day, for example, the pathologist at Michael Reese Hospital, who surveys the causes of disease as revealed after death, pointed out that it is now more difficult for him and his associates to state the cause of illness because these hormones and other drugs have profoundly affected the structure of the body as they cured diseases often fatal hitherto. And these drugs and hormones as you know, were created, just like insulin, by investigators utilizing animals.

The importance of the cardiovascular problem has been demonstrated by its appeal to the public. About 1946 the amount of money that was invested by national agencies and the government in research on the heart was almost nothing. Then by an act of Congress there was established a National Heart Institute in what is now known as the Department of Health, Education and Welfare, as part of the National Institute of Health in the Public Health Service. And last year Congress appropriated about $15,000,000 for the control of and for research on heart disease. It was not too difficult to convince the Congressmen to appropriate this sum in a period of Republican budgetary constriction, because they felt that this was a good investment for them as representatives of the people. Now a great deal of that money goes for animal research. Why? Because it is felt, when one is unemotional about the thing, that this is the place from which new knowledge will come. I conceive of the patient as the consumer of medical knowledge, the physician as the retailer, and the investigator as the manufacturer. You cannot give the consumer "new" goods in knowledge unless it is created, and research is the creator of new knowledge.

Simultaneously with this movement in government, the American Heart Association which was established in 1922 as a learned professional society such as yours, for the exchange of knowledge, clinical and scientific, decided that it should enlarge its scope and become a voluntary health agency. It was felt that physicians and scientists should take leadership as citizens in what was and is still considered an important movement in the best interests of the public. And so it was reorganized and became the fastest growing large voluntary national

health agency. It is trying to expand in its appeal for funds only as fast as it can spend wisely the money so raised. Starting a few years back with the "Walking Man"—Jack Benny on radio—which brought in about $1,500,000 to organize and start a program, the funds collected annually have gone up to over $8,500,000 last year. This amount was raised in this country by voluntary contributions. The national organization allocates one out of every two dollars it receives to research. This is the largest contribution made towards research by any of the national voluntary health agencies. A good deal of the money goes to support men. We have three life-time career investigators supported by the Heart Association. One is a physiologist at the University of Minnesota who deals with the energetics of the heart; one, a physiologist at Harvard who deals with the dynamics of the small blood vessels and the transport of fluid through them; and the third, a microbiologist at Harvard who deals with the problems of immunology as they apply to heart disease. Each of these three gentlemen receives $12,000 a year from the Heart Association practically on a life contract. $7,500 is available annually for the work of each, and the institution receives $1,000 for overhead. This is a great investment the Heart Association believes. We are implementing the idea that brains are what we need in this research field. And there are several score of established investigators on five year appointments whose salaries range from $6,000 to $9,000 per year. In addition there are research fellows, and grants-in-aid are made. Last year we spent close to $1,000,000 for research, and the affiliates of the American Heart Association, including the Chicago Heart Association, are spending much more than that in their local areas. All this can be found in a book just published by Mr. Blake Cabot who travelled around the country to find out "what makes Sammy run" in research. As a good reporter and a sympathetic one, he informs the public what the motivations are of the people who create new knowledge, and the picture is a pleasing one.

At a recent all-day meeting in New York for the cardiac-in-industry program and at a similar meeting here in Chicago a year ago, the theme was how we can help the cardiac to live the full life, which includes work as well as play. The information that was transmitted at these conferences which were attended not only by physicians, but also by labor leaders, personnel managers, nurses, teachers, social workers and representatives of all the academic professions, was very valuable. The theme song presented was in part that heart disease does not develop from ordinary work. Part of that judgment as well as others came not only from observations on human beings but from the study of the application of stresses to animals.

In the last thirty-five years since I have been in the research field,

the advances in management of heart disease have been remarkable.

Let us consider congenital heart disease. It is now clearly established that these malformations of the heart, with which youngsters are born, are often the result of German measles occurring about the third month during the mother's pregnancy. Many of these malformations have now been remedied with surgery. For this purpose, operations have been developed like that of Dr. Blalock at Hopkins, of Dr. Potts here in Chicago, of Dr. Gross at Harvard. The preliminary experiments to develop these procedures have been done on animals before human beings were subjected to this surgery. These animals have served as guinea pigs for the weal of the most important animal species, man. The preliminary experiments on animals have been done by the same people who then carried over these procedures directly to man. I happen to be such a person. I distinctly present myself as exhibit "A" to counteract those emotionalists who for one reason or another fight such advances. Their actions are not in the best interests of society.

In connection with congenital heart disease there has been the need of putting a catheter, a tube, into the heart. This was first done on himself by Dr. Forsmann in Germany to demonstrate that it was not risky. But even before this, its utilization had been explored in animals. Now in this country following the work of Dr. Cournand, thousands of patients have had their hearts literally explored with these tubes. At Michael Reese Hospital we have now examined about 450 patients with this technique and are continuing to examine them at the rate of three or four each week. This is for their benefit to explore the possibilities of treatment including surgery.

In this connection, cooling of patients before surgery is being tried. Where was this first tested? Not on patients, but on animals.

Rheumatic heart disease is one of the major forms of heart disease. Recently investigators in this country and abroad formed a committee which has been studying the effects of cortisone and ACTH on the process in patients. Recently it has been shown that prevention of this disease can be produced with penicillin and other antibiotics. Where were some of these preliminary testings done? Not on human beings, but on animals.

Very closely allied to rheumatic fever is the disease known as subacute bacterial endocarditis, the organism of which is the streptococcus viridans. Its biology is fully understood; yet despite this knowledge I recall not too many years ago, before 1946 to be exact, that practically every victim of this disease died—and these were nice, attractive, young people. It used to make me "heart sick" because all we could do was to make out the death certificate, sign it, and leave only the date blank. Now with these antibiotics, the least optimistic

figure for cure and survival is 75%. Our own experience is more nearly 85% survival. We have followed these cases some seven years, and now, they are still alive. How was the preliminary information obtained? Why, from animal experiments, of course. I recall very vividly some experiments we carried out on dogs in which we implanted this infection in order to test other drugs. This was before penicillin became available.

In rheumatic heart disease a marvelous operation has been developed for overcoming the defects of the valves. I was in Philadelphia not so long ago and had the privilege of "scrubbing" with the surgeon who recently helped to develop this plastic operation. It was strictly a matter of inserting his finger and loosening up the valve so that the obstruction was overcome. The results are remarkable. The number of people who have been helped by this operation is amazing. How was the first knowledge of this sort of surgery obtained? From animal experiments, of course. The man who acts as the scientific guide to this particular surgeon mentioned, was trained in my own department, and several of the other such people in other parts of the country were also trained in laboratories, and so too were the surgeons. The same doctors who treat human beings studied animals; they learned how to treat man from their experience with lower animals. These lower animals were used to advance knowledge for you and me.

Let us consider syphilis. Syphilis now-a-days, as far as blood vessels and the heart are concerned, is inexcusable because it can be treated adequately in the primary stage with antibiotics. The only reason that syphilis will persist for a few years is that this knowledge is only recently acquired. In twenty years only those who are careless and ignorant will develop syphilitic heart disease. Antibiotics—where do they come from? Out of some person's imagination or out of research?

Let us look at high blood pressure. High blood pressure is one of the mysteries today. It is estimated that about two or three million people in this country have it. It varies in form. Therapies of various sorts have been applied and some are gaining some credence. Surgery on the nerves going to the blood vessels has been tried and in certain cases is effective. Certain operations on the adrenal gland are useful in selected cases. Were these first tried on man? Of course not. They were first tried on animals. Dr. Grimson working at the University of Chicago did the most extensive sympathectomy on dogs before doing this operation on humans. Dr. Smithwick of Boston who has the largest experience with this on some 1,500 human beings, got his start by trying the operation on animals first. The work of Dr. Goldblatt of Cleveland tends to point to high blood pressure being of kidney origin; he did his brilliant work on the dog, and the impetus he gave to this field was tremendous. One day as our understanding of

this disease advances, it will repay us greatly. I have participated in panels of scientists in this country and abroad dealing with this subject and have heard certain questions repeatedly: What is this disease? What can we do about it? How do we prove our point? Was it checked on animals?

Finally I would like to talk about hardening of the arteries, because that is closest to my heart. I was brought from Western Reserve University to Michael Reese Hospital to study coronary disease, the great killer that causes heart attacks. I started out by studying the physiology of the coronary arteries and the electrocardiogram of animals and man.

Because in my work at Michael Reese Hospital I came into intimate contact with patients, it constantly kept reminding me that we should deal with fundamentals, and so about twelve years ago we set up a chicken colony. To study hardening of the arteries we maintain 400 to 600 chickens in this colony, and have examined many thousands for this purpose. We have just published a scientific monograph on our experiments in arteriosclerosis, containing knowledge which we hope will be applied to man soon. Some of this knowledge was obtained from rabbits and some from dogs. What is our motive? The motive is to find out what this all important disease is. We among others have established that hardening of the arteries is not just growing old. It is a disease of metabolism, and the offending agent is cholesterol, not only the cholesterol in the diet but more important the cholesterol that is manufactured in the body. In this disease cholesterol gets into the artery walls, cuts down the lumen, permits them to ulcerate and allows clots to form. Recently, we carried out an experiment with Dr. Gould of Los Alamos, who brought some isotopes to inject into our chickens so we could study the intermediate metabolism of cholesterol. Recently work has been started with isotopes at the University of Chicago along these lines on patients. Among our most interesting studies are those concerning hormones. The thyroid, the pancreas, the adrenal and the pituitary have effects on this disease in chickens. Since we say that the chicken is like man in many regards, the implication is that this is applicable to man. An experiment which takes two or three months in a chicken would take a number of years to do in a man, and in our civilization one does not kill men to see what their blood vessels look like. Our civilization says it is just as important to kill chickens to look at their blood vessels as to kill them for food, provided that the killing is painless and done in the best interest of man.

We have found exciting results with sex hormones. In closing I would like to tell you about this because it will pinpoint the way a possible major advance is made. It is known that under the age of

forty, hardening of the arteries is something like twenty times as frequent in man than in woman, so that one can say this is a disease of the male. We found that in chickens too, the male was more vulnerable than the female. We have just completed a study in which we found that egg-laying hens could tolerate this offending agent, cholesterol, in their diet more readily than roosters. We have given male chickens female sex hormone at the same time we fed them cholesterol. Examination of their coronary arteries showed that female sex hormone prevents the disease. We now say, it is not a disease to be a male, but it is healthy to be a female. We have not only been able to prevent hardening of the arteries of the heart in chickens, but we were able to demonstrate in the young male chickens that when the coronary lesion has developed, the lesions disappear when we give them female sex hormones. Obviously, male birds tend to become feminine on this treatment. We therefore carried out some experiments combining male sex hormone with female sex hormone and I can report that we were able to prevent feminization in these chickens and still prevent coronary artery hardening. We believe that this is so important that we are now testing this therapy on young males under forty who have survived a heart attack. We now have some eighty such patients and we are going to study several hundred more, following them to see if there is any significant effect. These patients are cooperating wholeheartedly in this study. Of course, we hope that the results in man will be as good as in the chicken.

For an investigator who has spent thirty-five years in research, as I have, the satisfaction of such a pos ible practical result is apparent. This is the aim of all medical investigators—to do something to help mankind.

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## RIDER PUBLISHES *HOW TO USE METERS*

A new book titled *How to Use Meters* written by John F. Rider has just been published by John F. Rider Publisher, Inc. of 480 Canal Street, N. Y. 13, N. Y. Shipments are being made to the Rider distributors and book stores.

*How to Use Meters* is a 160 page text with 160 illustrations and sells for $2.40. It is devoted to the application of all kinds of panel meters, volt-ohm-milliammeters and vacuum tube voltmeters for TV and radio servicing, transmitter installation and repair, laboratory practice and industrial applications. It is a completely practical book with special emphasis on "where to measure" and "how to measure" and "with what." The author makes a special effort to explain the differences between meter type measuring equipment of all kinds, stating what they can do and can't do. In every way the book is *tailored* to fit the needs of the personnel for whom it was written. It is a specially valuable book for teaching purposes because the illustrations showing the application of the measuring devices follow a point-by-point and step-by-step procedure for the different kinds of equipments.

A feature of the book is the discussion of the testing of electronic components. Many confusing situations are explained. *How to Use Meters* is the kind of book that has daily application. There are eleven chapters in the book.

# A SOCIAL CONSCIENCE FOR SCIENCE TEACHERS*

EARL K. PECKHAM
*Formerly Director of Training Material Division*
*Federal Civil Defense Administration*

Most of scientists I see today look worried. Popularity is a worrisome thing and believe me scientists are popular in Washington—and I hope in Illinois and California. If we were rationing choice cuts of steak we would give extra stamps to scientists—the Communists do. If we had exclusive beach resorts, they would be reserved for scientists—Russian scientists have such special beaches. National leaders in all countries are saying in effect, "Speak softly and carry the best scientists on your Government payroll."

It would be too big a job to review all the research, the projects, the multiple studies now going on in the interest of national defense, offense, transportation, communication, nutrition—all of which are helping to make our country safer and a more effective world leader among nations. We are looking inward to make our country strong—and outward to help other nations and make a more harmonious world. Both views are now national policy that can only be carried out with the help of scientists.

I will, just for an example, give a brief account of six major postwar projects in which science has played a principal role. All are related to defense and all have involved the best in scientific brains available. I'm not suggesting these are the most important projects science is concerned with. I am just giving examples.

*Project Charles*—A preliminary investigation of air defense of our cities, carried on at the Massachusetts Institute of Technology under the direction of Dr. Wheeler Loomis, head of the physics department at the University of Illinois. It urged further action by our scientists and military experts.

*Project Lincoln*—Established at M.I.T. as a consequence of the Project Charles report. The Lincoln Laboratory, outside Boston, now engaged in intensive research and development work, designed to improve America's air defense weapons and America's vulnerability to massive atomic attack.

*Project East River*—A study of the problems of civil defense, carried on under the direction of Associated Universities, which operates the Brookhaven National Laboratory, Brookhaven, L. I. This project made an intensive investigation of the effects of a heavy atomic attack on New York City.

*Project Vista*—A study of military tactics and new weapons, with

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particular attention to the defense of Western Europe. The work was done at the California Institute of Technology, under the general direction of Dr. Charles C. Lauritsen, professor of physics and an expert on rocket development.

*Summer Study Group*—An offshoot of Project Lincoln. Primarily a discussion and study group, led by Dr. Robert Oppenheimer, it directed itself to an examination of the present status of American defense capabilities, and recommended an emergency program for the defense of our cities.

*Project Hartwell*—An examination of the Navy's tactics and weapons problems, led by Dr. Jerrold Zacharias of M.I.T. Many of its recommendations have already been put into effect by the Navy; others are under consideration. The Hartwell study is one of the oldest postwar defense projects.

Because the Summer Study Group has definitely lifted our sights as to the part that science will play in defense, let me give you what details I know of their report.

It was this Summer Study Group that produced, late last year, the most complete and the most startling of all the reports on defense against the Russian atom threat. This group of scientists held out the hope that, at an admittedly large cost, a defense system could now be put into being that would destroy a large proportion of enemy weapons launched against this country—as much, conceivably, as 85 or 90 per cent. Such a defense system, wedded to civil defense measures and the dispersal of targets to the extent that such dispersal is practicable, could save this country from immediate devastation.

How was this to be done? The details are necessarily secret. But in their bare outlines, they can be estimated.

First, an early warning radar network, extended thousands of miles beyond the continental limits of the United States at the Arctic Circle and far out at sea. Incoming bombers will be traveling at 500 miles an hour. They must be picked up, identified and pinned down as to course, speed and probable target, before interceptors can rise from the ground and move out to intercept them far from their goals. Each 100 miles is 12 more minutes for the defending force. Only in recent months has there been reason to believe that techniques can be developed to do this amazing job.

Second, a network of automatic calculating machines—"mechanical brains"—collecting and collating the radar information in seconds, and issuing the orders for counteraction. The information that radar can deliver is valueless as long as it remains merely raw information; it must be interpreted, it must "make sense." Conventional means of communication and calculation are simply not fast enough to do the job. The drain on manpower, alert and at action stations 24 hours a

day every day of the year would be incalculable.

Third, investigation of the possibility of making interception entirely mechanical. Radar would bring information of the attacking planes, calculating machines would interpret it, and then the machines themselves would launch guided missiles at the invader. In such matters, the human hand and the human brain are imperfect and dilatory (which should be no measure of inferiority, since it is the human hand and brain that build the machines).

Fourth, and this can be nothing but mere guesswork, perhaps some new techniques of interception to which no clue is as yet public. By the very nature of military security, new weapons, if they are in the making, constitute the most precious of our secrets. Dr. Berkner spoke recently of a "technological break-through"; what he meant by this only Dr. Berkner and his colleague can say.

This major review of the activities of scientists in one field of national concern, defense, gives us some reason for saying that scientists will continue to be popular. If scientists are to take on this type of assignment, given to them by their nation and world, then they must also be in a position to influence the very type of assignment, its goals and value; otherwise scientists will find themselves slaves of political and social leaders—genii whose strength is used by those holding the government lamp of purse and power.

In other words, the scientist finds that he needs social wisdom in order to be a good scientist—a wisdom applied quickly and applied in all his scientific research and teaching. If he does this, he will be an important factor in saving modern man, and he will save his own soul—his self-respect. If not, he may be simply an instrument to destroy his fellow men. Those he destroys are his fellow men, even if for immediate purposes we call them enemies.

Scientists, I repeat, are worried; they want to do a better job of making science a constructive man-saving force in society and do it rapidly enough so as not to allow society to plunge off the very obvious cliff that lies ahead.

If scientists are on this kind of a spot, then science teachers have a great responsibility of developing in the future a type of science thinking infused with social purpose.

In the thirties, Robert Lynd of the History Department at Columbia, wrote a provocative book to social science teachers entitled, *Knowledge for What?* I was working with Lynd at the time, and we took hikes into the rolling hills of New Jersey and Westchester County, North of New York. He is a great talker. I profited from listening. It was his theme that social science teachers had a moral responsibility to point out to students what were constructive movements in history and what were destructive—and he believed it

wasn't too difficult a task to see which roads led to freeing of man and which to his entrapment. Because social science teachers were themselves a product of their own society, he exploded the myth that they could approach the study of history in a purely objective way. To a degree, all teachers teach from a biased point of view—why not examine our biases and use our judgments to select those biases that support creative democratic living. His answer to the question, *Knowledge for What?* was *Knowledge for Creative Democracy*. His book made good sense. This was a challenge to social studies teachers, calling for some self-evaluation and a better understanding of what lies ahead for democracy.

Today the same challenge cuts deep into the conscience of science and mathematics teachers. They must have a satisfactory answer to the question, "Science for What?" The scientist is no longer the man in the lab smock. He is asked to take effective moral action in a complex society. If he understands his task, he will seek wide knowledge and sophistication that scientists of the past have many times considered outside of their responsibility.

Taking effective action to meet one's responsibility needs the same careful study, planning, execution and evaluation that any scientific experiment or mathematical problem needs.

A cartoon in the *New Yorker* recently showed a man seated at a kitchen table with one hand on an empty whiskey bottle and his head drooping almost to the table top. His wife at the kitchen door was saying to a neighbor, "That's Henry's answer to the atomic bomb."

Science teachers might be tempted to use their own formulas, beakers and bottles as similar pacifiers when it comes to facing their responsibility in an atomic age.

But this paper is not an attack on science teaching or teachers; it is rather an attempt to state the problem of wider responsibility and to urge you to consider teaching methods and curriculum development that will center math and science teaching on these current responsibilities, shared by all educators. If your science and math and all your scientific methods can't help us to solve major human problems, then I join Wordsworth in saying:

> "I'd rather be a pagan
> Suckled in a creed outworn
> So might I standing by this pleasant lea
> Have visions that would make me less forelorn."

For me, if I have to choose between worshipping a tree under which I can find shade from the hot sun and the formula that releases an atomic explosion over a densely populated city, I'll choose the tree. So would anybody who is interested in man.

We don't have to make such choices, however. We have indeed enough experience and vision to direct science and control it in its proper place—into the what promises to be a glorious future for mankind. By giving science a social conscience. Teachers can help do this.

It seems to me that science and math teachers have two major responsibilities in our educational world:

1. To teach large numbers of students the contribution of science to modern living and the increasing role of science in the future development of all nations. This will bring some basic methods of scientific thinking into the lives of all students. This general education should place science in its proper social role.
2. To encourage, through good teaching and good guidance, selected students whose ability and interest give promise of successful careers in science. Here too a high degree of social sensitivity should be developed—and that can start in the secondary school.

I don't need to waste your time in telling you how to teach science and math. You know that. I can, however, point out to you what I think are some of those areas of social conscience which must be understood and made a part of science teaching.

In the time available, I can only touch on two or three areas—and I'll confess I shall talk about those areas closest to my heart. I'm judging them as of utmost importance in today's world, and we need to understand them, both as a part of general education and as studies of high specialty.

I'll tell you a true story that happened in a suburban high school just outside of Washington. In a discussion about the need for civil defense, a teacher said to her class, "If an atomic bomb fell in the school yard, we would have quite a problem." This is the understatement of all time. I admit that this happened before many of the same pupils had seen the bomb tests on TV, or they would probably have told the teacher something more about the "problem."

Teachers must capture the size and significance of the part science is playing in today's world. In any study of atomic energy we must try to give a wide scope of understanding. As the teacher says, "It's quite a problem." It's a problem that involves the facts of atomic structure, release of neutrons, heat of the fire ball, blast, radiation. Then there are the facts of destruction—human factors, international implications, religious convictions, national interests. I'm not suggesting that teachers stop and make detailed study of all these implications. I'm simply saying: let students know that these facts of scientific discovery have made complex problems for their world—problems that need solution and need their best thinking. Take time in your science teaching to discuss these things. They are important.

Believe me, if anything is going to control this weapon which we now hold, it is the minds of men who understand, and you know *we must control this weapon.*

In 1947, I visited the sight of the school house in Hiroshima, a few hundred yards from ground zero. Concrete walls stood firmly enough so that fresh wooden floors had been laid and school was going on there among the ruins. The principal told me the story in very poor English. The children and teachers were there on That Terrible Day. They were in their classrooms, 600 of them. In a fraction of a second all traces of humanity were gone—disintegrated by a new force released in our world. I agree with the American teacher that if an atomic bomb were to drop in the school yard, there would be quite a problem.

Please forgive me if I don't spend time on the constructive uses of atomic energy. You know them—they have great social significance and should be taught and used to give needed hope in this world.

Another major world problem is bringing practical science principles to bear on producing more healthful living for millions now in degradation. These millions, in many cases, live in countries well suited to more abundant harvests if water were more available, agricultural methods improved, diseases controlled, insecticides used widely, and the people given the simple facts of sanitation. Their mineral resources stand idle waiting for industry to use them—waiting for the application of science. Your students need to have opportunity to see how the WFO, WHO, UNESCO, and private foundations are using science to help with these problems.

Because Government budgets are for one year, and because sometimes Federal administrations last only four years, we may make the mistake of thinking that these worldwide problems of starvation, widespread disease and misery can be solved quickly. We have dramatic stories currently coming in from all parts of the world of progress—resulting in a rising level of living for millions. But it's only a beginning. This has not come simply from the generosity of the U.S.A., but to a large degree from the rising understanding of the contributions of science to living on the part of native leaders and groups. We do have great pride in the contributions given to this progress of American men and women and the money flowing into the programs of MS and TA. I personally think our national interests are greatly protected, but I also believe that to build foundations for democracy in parts of the world where they have no great democratic tradition will take many generations. We cannot rely on only men trained in military tactics to solve these problems. The greatest help will come from men who know how to apply scientific knowledge,

and who will plan and work together with native groups over long periods of time.

I would like to see young men and women in our schools understand this epic story of the application of science to these world problems and, in some cases, see those of the highest ability plan careers in these fields. The democratic world needs them.

When we teach the application of science in the solution of these world problems, we should teach the obvious facts that scientists come from all countries, all races, both men and women. It will bring students a true understanding of the universal, when they see scientists of America working with scientists of all nations—including those from the so-called undeveloped countries. Science teachers stand in an excellent position to teach true world citizenship. Let's not make the mistake of misjudging the contributions to science that come from the minds of all men, regardless of origin. Let's not forget our obvious American debt to the scientists of the past who worked faithfully in foreign countries while our greatest concern was opening the physical frontier, or even before we were a nation.

The last area of our modern living, I shall mention, which needs the conscious consideration of science teachers is the use of scientific thinking to interpret the political and economic affairs of our country. This spring a congressman requested an investigation to discover if there were a relationship between the devastating tornadoes in Michigan, Massachusetts and Texas and the atomic bomb tests in Nevada. The highest ranking meteorologists, said, "It just can't be." But anyhow it looks as if there were to be an investigation. Who knows whether a certain additive will prolong the life of a storage battery? I hope the scientists do. I believe they do. Science gives honor to known facts, doesn't it? And it's good science, isn't it, to withhold judgment until the facts are in. Some will think that this is not good politics, but it is good science. I believe that it proves to be good politics in the long run. Were the ships once owned by a British company, rented to a South American company, which docked them at a communist Chinese port, under the control of British authority? Until the facts are known, judgment concerning the British wilfully helping communist China should be withheld—that is, if the member of Congress is scientifically trained. It's important that he be so trained in the future. He is sitting in your class. Are you helping him to use scientific thinking in this way? We should look to leaders who show evidence of applying good scientific methods to important decisions for our country.

These leaders and their committees will influence the affairs of our city, our state, our country, and they all need the clear eyes and

the patience to discover the truth and have the courage to act on it when it is established. Your students will listen to political speeches, look at TV's claims of merit in cigarettes, cold cream and power steering, and they will need the clear eye and the willingness to honor proven facts.

Bring these problems into your science teaching—your mathematics teaching. Don't be fanatic about it. Don't claim that science sees all, knows all, solves all, but teach that when the science we know is used by men, it can be a very blessed gift. You believe that—make your students believe it.

This kind of speaking may bring us into agreement on some general convictions, but it won't help our everyday teaching unless we go forward and try to agree on some methods of bringing more social purpose into science teaching. I really know the questions in your mind. How can we add anything to the already crowded curriculum? How can I personally keep up with the significant social uses of science and math? How can I avoid the criticism that I'm teaching social science and not science?

These are questions that can only be answered by teachers and a community that supports the schools. Both must be convinced that it is for the welfare of their students and their country that such social purpose be infused into science and math teaching.

Frankly, we may not be able to "cover" as much scientific content. But I believe that which is taught will become more a part of the life of the student, and in addition will form a basis for understanding significant social issues; and what is even more important, contribute to intelligent social action.

It does mean that science teachers will need to read and discuss widely in fields not always considered science—that politics, economics, sociology, world affairs, will have to become their common diet. But this activity will not be unrelated to their everyday teaching. In such fields will be found much of the material that will be usable in enlivening class work and bringing the social purpose into teaching.

This teaching will have to include content, which will be considered by some, the monopoly of the social science field. True, but it is getting a different treatment in your science class. I'm not suggesting here a core organization. No. I want this to be part of science teaching. I want pupils to see the scientist in the important role of helping to solve social problems. I want to maintain the care and system of scientific thinking, organization and approach, but I want the clever teacher to so teach that in his day to day remarks and relations with pupils he will show how his particular science is a useful social instrument.

Perhaps the most difficult problem we face is convincing our com-

munity that this emphasis is necessary. The public has a misconception of what science is. Teachers many times have encouraged this misconception.

Science and math teaching in the high schools has often and only been preparation for more and advanced courses. Sometime in the future when the pupil becomes "a scientist," "a mathematician" will be soon enough to ask how will he use his knowledge.

Any effort to bring understood social purpose into these subjects from the outset was considered by some to be a watering down process or soft pedagogy. There is no soft pedagogy in this. It calls for serious and imaginative consideration. Maybe one of the best ways of getting community support for this new view of science teaching is to consult with lay leaders.

So often citizen committees have been brought into the school to help decide what social science, what literature or what music should be taught. Science and math have been considered well established subjects, not to be touched. We have sealed off the science and math fields. Let's have lay consideration of this part of the curriculum too. Let's feel more keenly our responsibilities to have parents understand the reason for bringing social purpose into science teaching or teaching science itself for that matter. If the reasons are sound for teachers, they can be made clear and sound for parents.

Bring into your science and math classes the maps of the world—make it a common practice to visit projects in your community where science is contributing to the solution of a social problem. Invite community leaders into your class who are looking to science for help in these problems. You will be a better science teacher.

Many men trained in science have, late in their lives, taken to writing about the future development for society. So often the picture has been one in which science has changed men into soulless robots, relying on this or that mechanical device and that chemical to solve all the problems. The popular mind still thinks of the scientist taking over and creating a "popular mechanics" world. This view of the future is intolerably dull, even if it were possible, and the man on the street knows it would be full. He does not see the great new application of science to the really significant problems of feeding the now starving millions, curing the sick and bringing the freedom and joy that an insured peace would bring to the world.

Science teachers can do a great deal in their day to direct science toward these broad and human purposes.

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Are you a member of the Central Association of Science and Mathematics Teachers? If not, you are falling behind. Write Ray C. Soliday today.

# A FAMILY OF NUMBERS

ROBERT E. FLEMING
*Southern Okanagan High School, Oliver, B.C., Canada*

The numbers 2 and 0 have a characteristic which they share with no other numbers: when either 2 or 0 is multiplied by itself or added to itself the result is the same. That is, $2\times 2=2+2$, and $0\times 0=0+0$. The fact that 2 and 0 are unique in this respect can readily be seen by solving

$$x^2=2x. \tag{1}$$

There are, however, unlimited pairs of *distinct* numbers whose products equal their sums. One such pair is 4 and $1\frac{1}{3}$, since $4\times 1\frac{1}{3}=5\frac{1}{3}$ and $4+1\frac{1}{3}=5\frac{1}{3}$. Another pair is $1\frac{3}{4}$ and $2\frac{1}{3}$. By allowing $x$ and $y$ to represent the members of all possible pairs we obtain

$$xy=x+y \tag{2}$$

from which

$$y=\frac{x}{x-1}\cdot \tag{3}$$

Formula (3) may be used for all values of $x$ except $x=1$.

By substituting $x=2$ and $x=0$ successively in formula (3) we are able to verify the fact that the pairs (2-2) and (0-0) exist. However, by allowing $x$ to have other values, except $x=1$, we find that although (2-2) and (0-0) are the only *identical* pairs whose products and sums are the same, they are in reality only special cases in an inconceivably enormous family of pairs for which this fact, which at first seemed so unique, is true.

Further study of the formula brings out the fact that (2-2) and (0-0) also constitute the only *integral* pairs, since the values $1<x<2$, between which extremes there are no integers, produce the whole gamut of $y$ values $\infty>y>2$, and for $2<x<\infty$ we have $2>y>1$.[1] Then, with the exception of the two original cases, if one member of a pair is integral, the other cannot be integral.

It seems that most people who enjoy toying with our number system prefer to confine themselves to consideration of the integers, and particularly the positive ones. They are the aristocrats of the number system. However, two is a small family, especially in the prolific number society, and since we have already opened the door to the fractional relations, let us open it wide and take in as well the poorer

[1] Some redundancy exists here, since $x$ and $y$ are in a sense conjugates, for while $y=x/(x-1)$, it is also true that $x=y/(y-1)$.

relations—the negative, irrational, imaginary and complex numbers.

Negative numbers appear when $x$ is assigned any value less than $x=1$, except $x=0$. For $1>x>0$, $y$ has the values $-\infty<y<0$, and for $0>x>-\infty$ we have $0<y<1$. It will be noticed that either $x$ or $y$, but not both, may be negative, and hence all pairs for $x<1$ must be distinct except for the aforementioned 0-0 pair. A study of the ranges for $x$ and $y$ discussed in this paragraph also shows that no further integral pairs can exist.

Irrational pairs, such as

$$\sqrt{2} \quad \text{and} \quad \frac{\sqrt{2}}{\sqrt{2}-1},$$

as well as imaginary and complex pairs such as

$$\sqrt{-3} \quad \text{and} \quad \frac{\sqrt{-3}}{\sqrt{-3}-1}, \quad \text{and} \quad 5+\sqrt{-6} \quad \text{and} \quad \frac{5+\sqrt{-6}}{4+\sqrt{-6}}$$

also satisfy the required conditions.

The graph of $y=x/(x-1)$, shown in Figure 1, serves merely to emphasize what has already been said of the real-value pairs. The graph lies in the first, second and fourth quadrants. In the first quadrant both variables are positive, while in the second and fourth quadrants

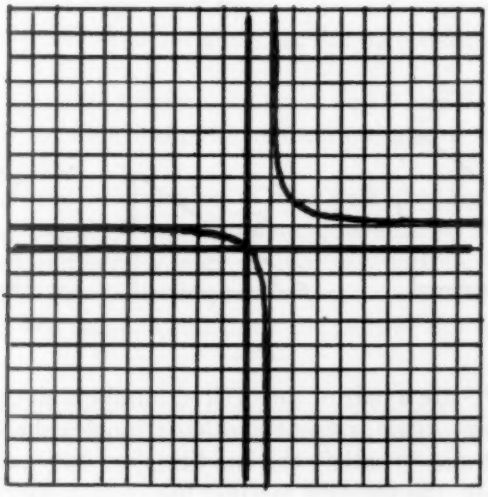

FIG. 1

one variable is positive while the other is negative. The graph passes through the points (0, 0) and (2, 2). As $x\to\pm\infty$, $y\to 1$, and as $y\to\pm\infty$, $x\to 1$.

Though the above procedure is the most obvious one for finding all the desired pairs, there exists another approach to the problem. In high school trigonometry a popular identity set out for proof is

$$\sec^2\theta \csc^2\theta = \sec^2\theta + \csc^2\theta.^2 \tag{4}$$

Let us consider $\theta$ to be an angle adjacent to the hypotenuse of any right-angled triangle. For example let us use the 3-4-5 right triangle, with $\theta$ opposite the shortest side. In this triangle

$$\sec^2\theta = \frac{25}{16}$$

and

$$\csc^2\theta = \frac{25}{9}.$$

Thus

$$\sec^2\theta \cdot \csc^2\theta = \frac{25}{16}\cdot\frac{25}{9} = \frac{625}{144}$$

and

$$\sec^2\theta + \csc^2\theta = \frac{25}{16} + \frac{25}{9} = \frac{625}{144}.$$

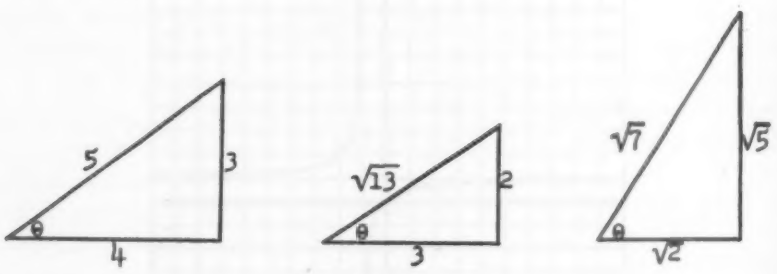


FIG. 2

Hence $\frac{25}{16}$ and $\frac{25}{9}$ are a pair of the desired numbers since their product equals their sum. Again, using the other triangles shown in Figure 2, we find that $\frac{13}{9}$ and $\frac{13}{4}$ satisfy the condition, as do $\frac{7}{5}$ and $\frac{7}{2}$.

Unfortunately, the identity method has certain shortcomings. The 0-0 pair cannot be found from it by using real values of $\theta$, and neither can any pair in which one of its members is negative or less than 1. The reasons are that neither $\sec^2\theta$ nor $\csc^2\theta$ can be negative and that $\sec\theta$ and $\csc\theta$ never have absolute values of less than 1. In other

[2] This identity has the same form as formula (2).

words, the identity will provide only those pairs of numbers which are shown in the first quadrant of the graph of fromula (3).

A study of the examples derived above from the identity brings to light the fact that if any given pair of numbers is rewritten in common fraction form, with mixed numbers changed to improper fractions, and each in its lowest terms, then the numerators of the members of the pair are equal, and the sum of the denominators is equal to the common numerator. Hence $1\frac{3}{4}$ and $2\frac{1}{3}$ become $\frac{7}{4}$ and $\frac{7}{3}$. The numerators are the same, and $4+3=7$. Moreover, 2 and 2 become $\frac{2}{1}$ and $\frac{2}{1}$, and the same situation exists. $\frac{9}{1\frac{9}{3}}$ and $-2\frac{1}{4}$, a pair containing a negative member, become $\frac{9}{1\frac{9}{3}}$ and $\frac{9}{-\frac{9}{4}}$, in which the sum of 13 and $-4$ is 9, the common numerator. (It is not possible to manipulate the 0-0 pair in this way.)

Thus to derive a pair of numbers to fit the condition that their sum is equal to their product we need only follow a simple procedure: Select any two numbers and designate them as denominators. Then add the numbers chosen and place this sum in the numerator of each fraction. If the denominators are 2 and 9, the numerator of each will be 11 and the numbers required are $\frac{11}{2}$ and $\frac{11}{9}$ or $5\frac{1}{2}$ and $1\frac{2}{9}$. If $-3$ and 4 are the denominators, the pair will consist of $-\frac{1}{3}$ and $\frac{1}{4}$.

## Summary

1. A family of numbers exists in pairs such that the product of the members of a pair equals their sum.
2. The only identical pairs satisfying the requirements are 2 and 2, and 0 and 0.
3. The only integral pairs are 2 and 2, and 0 and 0.
4. Except for the identical pairs, not more than one member of each pair may be integral.
5. Not more than one member of each pair may be negative.
6. The pairs may be real or imaginary, rational or irrational.
7. When the members of a given pair are written as simple fractions or improper fractions in their lowest terms, the numerator of each fraction is the same, and equals the sum of the denominators.

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Reversible window shade is made of a flexible plastic with a rich box grain design. One side of the shade is a light color, such as cream, and the other side is dark to harmonize with exterior colors. Light does not penetrate this material, which resists sunlight, rain, air, moisture, mildew, insects and most chemicals.

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Utility cart is an all-purpose device for suburban living. Its removable canvas bag is useful while gathering laundry, dead leaves or trash. With the bag removed, the cart becomes a hand truck, weighing only 25 pounds but capable of hauling 200-pound sacks or cans. Its framework can be collapsed for storage.

# TEACHERS TAKE TO THE WOODS

JAMES SANDERS
*Chicago Teachers College, Chicago, Ill.*

Incredible Chicago, the fabulous queen of the lakes, does it again. Chicago Teachers College, supported by the people of Illinois and the Cook County Forest Preserve District, owned by the people of Cook County, have joined hands and spirit. The college in teaching people how to live[1] needs the forest preserves which are dedicated to the use and happiness of those folk who love nature and seek the contentment and solitude of the green temples that are our natural woodlands. The sympathetic cooperation between the college and the forest preserve district is offering to all inservice teachers in Illinois[2] an opportunity to live in a permanent nature camp, of adequate facilities, as a summer vacation, a vacation which is in reality an education. Learn the lore and wisdom of nature by living intimately with plants and animals in the peace of the wilderness. When you leave the woods to go back to your schoolrooms carry a love and appreciation of the wild things you have known—small creatures which creep and crawl and swim and fly. Cherish the memory of the silken rustle of leaves of some favorite tree or the color and fragrance of a hidden bower of wild blossoms. Listen to the song of the brook as it tumbles through the rocky gorge in a frenzy of hurry to join the larger stream below the bridge. Sit and listen to the blended melodies of the birds as you dream your dreams and the bright images of your hopes glide past—beckoning—come on! Rest on a stony ledge and look down into the cool, green, depths of pure water to watch a fish drift by. All of this is yours. And when the canopy of dusk has lowered, raise your face toward the twinkling pinholes in the dark sky while the muted roar of the distant city is only a murmur interrupted by the little noises and tiny voices of the night. Return to the woods again and again if only in memories, but come back—oh come back to the out of doors. Memories . . . knowledge. . . .

Where and how can you achieve this? Is it possible near a great city? Camp Sagawau is located near the junction of Illinois Highways 83 and 4A. It is an established modern camp with dormitory cottages, central kitchen and mess, and an adequate lodge, which can be used as an auditorium, library and recreation center (dancing, movies, etc.) This camp is owned by the Cook County Forest Preserve District and reserved for educational uses only. Every hour a bus to the Loop passes within a short stroll from camp.

There is no cost other than for one's own food. The expense of this and of its preparation will be prorated. Food costs will not in any case be more than $20.00 each week. An expert and experienced person will superintend and operate the kitchen and mess hall.[3]

It is planned to offer a different and basic non-technical 2 hour course for each 2 weeks of the summer. This is done by continuing classes into the early evening and on Saturdays. It is thus possible to get 8 hours of senior college biology electives,[4] in an 8 weeks session, at a cost which is nominal. Each course is complete and one may choose any or all of the two weeks periods which best suit summer plans.

Nearby swimming facilities are excellent and a few good fishing waters are

[1] Several if not all of the major areas of the functions of living outlined by the division of curriculum (Chicago Board of Education) impinge upon this ideal.

[2] Anyone is welcome but Illinois statutes require repayment from non-residents of Illinois. C.T.C. instruction costs for 1952–53 were $550. Using this as a base, tuition for 8 weeks (½ semester) is $137.50 for non-residents of Illinois.

[3] Actually a lunchroom manager-cook from a Chicago elementary-vocational school lunchroom. She has for several summers been in charge of the cuisine at a luxury camp for girls.

[4] These courses can be used as upper division science electives, graduate level courses for the Masters degree in the teaching of biological sciences for promotional credit and for enriching and broadening fields of personal interests.

accessible only a few minutes hike from the camp.

Nature education has become of increasing significance and interest the country over. The literature is voluminous. Although the idea is not recent its development is not spectacular because of a need for experienced and trained teachers.[5]

Here is an opportunity to get your feet on the ground—literally. There will also be time, each day for recreation and rest. The camp is not open to the public and visitors will be excluded during days of instruction, guaranteeing privacy and the opportunity to learn.

At least two forest preserve naturalists in addition to the college faculty will be part of the instructional staff, also resource experts may be brought in. A forest preserve district bus with a capacity of 40 passengers stands by to carry you to any place in the 40,000 acres of forest preserves where illustrative material is most readily available.

This is in itself a very great learning and experience potential: 40,000 acres of bogs, swamps, ponds, sloughs, lakes, canals, springs, creeks, rivers, prairie, upland, forest, hill, flood plain, valley, glacial till—almost every type of habitat conceivable in the mid-western United States at this latitude.

Between the College, the Forest Preserve District Naturalists and the students there is an almost ideal workshop situation in which there is no delay, faltering, nor lack of active, qualified, interested, participants.

The Chicago Teachers College Natural Resources Sciences are offered only in the Cook County Forest Preserve District. The overall objective is to bridge the gap between the elementary classroom teacher untrained in any phase of technical science and the narrower fields of technological research.

Never before have two public institutions combined to offer so much, so freely, to so many.

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[5] "Teacher training is the bottleneck in the movement toward universal education in nature appreciation, nature lore, and conservation or wise use of our natural resources. Relatively few teachers feel competent to teach natural science and conservation, or integrate these subjects into existing units of study, because of their lack of background and training. They are still more reluctant to attempt excursions or field trips into natural areas out-of-doors. Until recent years, few teacher training institutions had required or even elective courses in natural history, field biology and conservation. Now, this deficiency is being gradually remedied. Some school systems and some states conduct workshops during the school year, or summer schools and 'conservation laboratories' which teachers in service may attend and for which they receive college credits. Training a teacher may be likened to energizing an induction coil—she attracts and motivates the pupils that come within her magnetic field." Annual Report for 1953 Forest Preserve District of Cook County Department of Conservation. Page 2.

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# PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
*State Teachers College, Kirksville, Mo.*

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.*

*All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor* should have the author's name introducing the problem of solution *as on the following pages.*

*The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.*

## SOLUTIONS AND PROBLEMS

**Note. Persons sending in solutions and submitting problems for solution should observe the following instructions.**

**1. Drawings in India ink should be on a separate page from the solution.**

**2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.**

**In general when several solutions are correct, the ones submitted in the best form will be used.**

### Late Solutions

**2393.** *Bro. Felix John, Philadelphia; A. R. Haynes, Tacoma, Wash.*

**2384.** *Nathaniel Grossman, Aurora, Ill.*

**2392.** *Norman Anning, Alhambra, Calif.; John Jones, Jr., Hattiesburg, Miss. Roy Wild, University of Idaho.*

**2391.** *Bro. Felix John, Philadelphia.*

**2389, 90.** *Russell H. Godard, Corvallis, Ore.*

Please Note. Longer Time for Presenting Solutions.

For this issue the solutions to **2395–2400** will not be presented. They will be presented in the next issue.

In the past solutions for problems of any issue are edited at the end of the month. This often permits less than a month for contributions to get their solutions in order. So in the future two months' time will be allowed.

This we hope will result in more problems being solved, better work done and fewer late solutions. We are in this issue offering proposals as usual. Their solutions need not be sent until the issue following the next.

### PROBLEM FOR SOLUTION

**2413.** *Proposed by Julian H. Braun, Washington, D. C.*

Show that $\cos 15^\circ = 4 \cos 5^\circ \sin 25^\circ \sin 35^\circ$.

**2414.** *Proposed by Felix John, Philadelphia.*

Solve the equations for $x$ and $y$:

$$(ax)^{\log a} = (by)^{\log b},$$

$$b^{\log x} = \log y.$$

**2415.** *Proposed by A. R. Haynes, Tacoma, Wash.*

Show that the distance between the incenter and the orthocenter of triangle $ABC$ is $2r^2 - 4R^2 \cos A \cos B \cos C$, where $r$ is radius of the incircle and $R$, the radius of the circumcircle.

**2516.** *Proposed by Martha Tobias, Springfield, Mo.*

Given a vertex, the orthocenter and the nine-point center of a triangle, construct the triangle.

**2417.** *Proposed by Robert Cawley, Dunmore, Pa.*

Solve the system for real values:

$$xy^2 = xy^4 = 90,$$

$$xy^5 + xy^7 = 2430.$$

**2418.** *Proposed by Norman Anning, Alhambra, Calif.*

If an ellipse intersects its evolute at the ends of the minor axis, what is its eccentricity?

# BOOKS AND PAMPHLETS RECEIVED

ELEMENTS OF STATISTICS, by H. C. Fryer, *Professor of Mathematics, Statistician, Agricultural Station, Kansas State College, Manhattan, Kansas.* Cloth. Pages viii+262. 14.5×23 cm. 1954. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $4.75.

INTERMEDIATE ALGEBRA FOR COLLEGE STUDENTS, Revised Edition, by Thurman S. Peterson, Ph.D., *Associate Professor of Mathematics, Portland State Extension Center, Oregon.* Cloth. Pages viii+369. 13.5×21 cm. 1954. Harper and Brothers, 49 East 33d Street, New York 16, N. Y. Price $3.25.

ALGEBRA, BOOK ONE, by C. A. Smith, *Chairman, Mathematics Department, Central High School, St. Louis, Missouri;* W. Fred Totten, *President, Flint Junior College, Flint, Michigan;* and Harl R. Douglass, *Director, College of Education, University of Colorado, Boulder, Colorado.* Cloth. Pages xii+500. 13.5×20.5 cm. 1954. Row, Peterson and Company, 1911 Ridge Avenue, Evanston, Ill. Price $2.72.

THEORY OF EQUATIONS, by Cyrus Colton MacDuffee, *Professor of Mathematics, University of Wisconsin, Madison, Wisconsin.* Cloth. Pages vii+120. 14.5×23 cm. 1954. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $3.75.

PHYSICS, THE STORY OF ENERGY, Second Edition, by H. Emmett Brown, *Professor of Science, New York State College for Teachers, Buffalo, New York,* and Edward C. Schwachtgen, *Science Consultant, Division of Curriculum Development, Chicago Public Schools.* Cloth. Pages xi+596. 16×23.5 cm. 1954. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $3.80.

AN ANALYTICAL CALCULUS, Volume I, by E. A. Maxwell, *Fellow of Queens' College, Cambridge.* Cloth. Pages xii+165. 13.5×22 cm. 1954. Cambridge University Press, American Branch, 32 East 57th Street, New York 22, N. Y. Price $2.75.

INTRODUCTORY COLLEGE MATHEMATICS, by Chester George Jaeger, Ph.D., *Professor of Mathematics, Pomona College,* and Harold Maile Bacon, Ph.D., *Professor of Mathematics, Stanford University.* Cloth. Pages xii+382. 15×23.5 cm. 1954. Harper and Brothers, 49 East 33d Street, New York 16, N. Y.

POWER OF WORDS, by Stuart Chase. Cloth. Pages xii+308. 13.5×20.5 cm. 1954. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $3.95.

MAN, ROCKETS AND SPACE, by Captain Burr W. Leyson, *Author of "Atomic Energy in War and Peace," etc.* Cloth. 188 pages. 13×20.5 cm. 1954. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York 10, N. Y. Price $3.50.

LABORATORY STUDIES IN BIOLOGY, by Addison E. Lee, and Osmond P. Breland, *The University of Texas.* Paper. Pages xi+253. 20.5×27.5 cm. 1954. Harper and Brothers, 49 East 33d Street, New York 16, N. Y.

THIS WE BELIEVE ABOUT EDUCATION. A STATEMENT CONCERNING EDUCATION IN AMERICA, by the Educational Advisory Committee and the Educational Advisory Council of the National Association of Manufacturers. Paper. 32 pages. 15.5×21.5 cm. 1954. 14 West 49th Street, New York 20, N. Y.

ALGEBRA BOOKLET, by C. A. Smith, *Central High School, St. Louis, Missouri;* W. Fred Totten, *President of Flint Junior College, Flint, Michigan;* and Harl R. Douglass, *Director of the College of Education at the University of Colorado, Boulder, Colo.,* 23 pages. 21.5×28 cm. Row, Peterson and Company, 1911 Ridge Avenue, Evanston, Ill.

INVITATION TO YOUTH. CAREERS IN LIFE INSURANCE. Paper. 32 pages. 15.5 ×23 cm. Educational Division, Institute of Life Insurance, 488 Madison Anuvee, New York 22, N. Y.

INTRODUCTORY COLLEGE MATHEMATICS, by Adele Leonhardy, *Chairman of the Mathematics Department, Stephens College, Columbia, Missouri.* Cloth. Pages ix+459. 14.5×23 cm. 1954. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $4.90.

COLLEGE ALGEBRA, Third Edition by Paul K. Rees, *Associate Professor of Mathematics, Louisiana State University,* and Fred W. Sparks, *Professor of Mathematics, Texas Technological College.* Cloth. Pages xiii+460. 14.5×23 cm. 1954. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 26, N. Y. Price $4.25.

FIRST COURSE IN CALCULUS, by Hollis R. Cooley, *Washington Square College, New York University.* Cloth. Pages xii+643. 14.5×23 cm. 1954. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $6.00.

METHODS OF ALGEBRAIC GEOMETRY, Volume III, Book V, by W. V. D. Hodge, Sc.D., F.R.S., *Lowndean Profewsor of Astronomy and Geometry, and Fellow of Pembroke College, Cambridge, and D. Pedoe, B.Sc. (Lond.), Ph.D. (Cantab.) Sometimes Charles Kingsley Bye-Fellow of Magdalene College, Cambridge.* Cloth. Pages x+336. 13.5×21.5 cm. 1954. Cambridge University Press, American Branch, 32 East 57th Street, New York 22, N. Y. Price $7.50.

CITIZEN CO-OPERATION FOR BETTER PUBLIC SCHOOLS. THE FIFTY-THIRD YEARBOOK OF THE NATIONAL SOCIETY FOR THE STUDY OF EDUCATION, PART I. Prepared by the Yearbook Committee, Edgar L. Morphet, *Chairman* and Others. Cloth. Pages xvii+304+vi. 15×23 cm. 1954. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill. Price $4.00.

MASS MEDIA AND EDUCATION. THE FIFTY-THIRD YEARBOOK OF THE NATIONAL SOCIETY FOR THE STUDY OF EDUCATION, PART II. Prepared by the Yearbook Committee, Edgar Dale, *Chairman* and Others. Cloth. Pages x+290+lxxvi. 15×23 cm. 1954. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill. Price $4.00.

ELEMENTS OF CHEMISTRY, by Raymond B. Brownlee, Robert W. Fuller and Jesse E. Whitsit. Cloth. Pages xviii+680+28. 14×21 cm. 1954. Allyn and Bacon, 2231 South Park Way, Chicago 16, Ill.

NUMBER: THE LANGUAGE OF SCIENCE, Fourth Edition, Revised and Augmented, by Tobias Dantzig, Ph.D., *Professor of Mathematics, University of Maryland,* (Retired). Cloth. Pages ix+340. 13×21 cm. 1954. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $5.00.

THE RADIO AMATEUR'S HANDBOOK, 31st Edition, by The Headquarters Staff of the American Relay Radio League. Paper. 800 pages. 16.5×24.5 cm. 1954. American Radio Relay League, West Hartford 7, Conn. Price $3.00.

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## WE ARE WEAK IN MATHEMATICS

Our Nation needs more and more persons trained in basic mathematical understandings. The high school enrollments indicate that this is not taking place. Even in algebra—the mathematics that is basic to an elementary consideration of quantity in any field of knowledge—the per cent of pupils enrolled is smaller each year. In 1934, 30.4 per cent of the high school pupils were enrolled in algebra. In 1949 there were 26.8 per cent and in 1953 approximately 24.6 per cent.

# BOOK REVIEWS

INTRODUCTION TO EXPERIMENTAL PHYSICS, by William B. Fretter, Ph.D., *Associate Professor of Physics, University of California.* Cloth. Pages viii+349. 14.5×23 cm. 1954. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $9.00.

This book has been prepared for the graduate student of physics, either as a text book or for reading if time is not available for taking the course. Much of the book is based on atomic and nuclear physics, hence many teachers in the small colleges and undergraduate courses in the universities will find it excellent help in keeping up to date in their physics education. The book is well illustrated by many excellent diagrams and the language is clear and explicit. A good short bibliography consisting of both books and journal articles, follows each chapter. The mathematics used in the theory discussions is clear and should cause no student or teacher in undergraduate work any difficulty. Since the subject includes such an unlimited amount of experimental techniques and the theory governing them one book can cover only selected portions. The topics included seem to be a well selected group and have been chosen by the experience of a number of years presentation by experts in the field. Just a few of the chapter headings will indicate the selection: Ionization Chambers, Geiger Counters, Nuclear Emulsions, Linear Accelerators, Mass Spectroscopy, Beta-ray Spectroscopy, Pile Techniques, and a few very important pages on Laboratory Hazards. The book is a valuable volume for any physics library.

G. W. W.

CHEMISTRY, A COURSE FOR HIGH SCHOOLS. Third Edition, by John C. Hogg, Otis E. Alley and Charles L. Bickel. Cloth. Pp. xi+772. 16.0×24.0 cm. 1953. D. Van Nostrand Co. Inc., 250 Fourth Ave., New York 3, N. Y.

The authors, three teachers in secondary schools of New England, state, "In (this) revised edition . . . (the book) has been almost completely rewritten. . . . Many changes both in content and in order of presentation have been made, largely . . . (thanks to) criticisms of chemistry teachers."

The organization is in terms of teaching units. After the introduction there are ten units. The first six "should be studied in order," the last four are so prepared that they are independent of each other. This permits the teacher to adapt the book's use to student interest or local need.

The topical sequence, after "Properties of matter (followed by) water and its constituents" lists "Carbon and its (inorganic) compounds" as unit three. Unit four, using some 100 pages, has to do with "Modern atomic theory." Ten chapters are used in this presentation. Two units upon non-metallic elements and their compounds round out the proposed units "to be studied in order." Of the remaining four units two are concerned with traditional organic chemistry. One of these four units, headed "Nuclei of atoms," gives "an emphasis consonant with (its) importance" to sub-atomic energy related to nuclear structure.

Ample evidence that the authors are teachers is given by an inventory of teacher-aids provided. Each of the fifty nine chapters has questions and problems at its end; many chapters have summaries in "Things to remember." Each unit has a battery of "Review exercises" at its close. At the book's end are six pages of questions and problems covering all ten units. Seven pages of "Glossary"; ten pages for four appendices and eleven pages of double-columned index give an impressive finish to the book's resources for effective teaching. Over 350 excellent well legended illustrations and diagrams, many of them full paged, and 131 demonstration-experiments fitted to the text content also belong in this census.

The preceding paragraph, however, does not tell the whole story. It is disappointing to find the diction, preface not withstanding, very generally of the implicit, "I am telling you" rather than the explicit "sharing the background with

the reader" pattern. The use made of the demonstrations is most frequently on the plan "this will show you" rather than "let's find out." The questions, quite generally, are seeking for recall rather than for integration or to probe for evidence bearing upon specific situations. The virtual fifty per cent use of numerical problems in the batteries of exercises seems to reveal a rather extreme confidence in the magic of numbers as a tool of chemical understanding. The Glossary, unfortunately, has many instances of over-condensed phrasing leaving either a half-truth or sometimes a distortion of meaning for the reader. To illustrate: alcohols, alpha particles, carbohydrate, chemical change, combustion, distillation, electrolyte and many others need a more critical editing. It is regrettable that in a book that seems so intent upon imparting information there is no recognition of any other source of chemical knowledge through suggested references. Perhaps that oversight has been rectified in the work book.

Even so, this reviewer is placing his copy of this book on his shelves with two other high school texts which he prizes above the average. As indicated in paragraphs three and four above, it has many attractive features which up-to-date teachers will want to use. With the encouragement that three editions imply future revisions may make possible some more "completely rewritten" secions.

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SPECULATION IN REALITY, by Irving F. Laucks. Cloth. Pages 154. 14.5×21.0 cm. 1953. Philosophical Library Inc., 15 E. 40th Street, New York 16. $3.75.

"Until lately," the author says, "(man) has thought and physics has taught that the original source of (what leads to sensations) . . . was something called matter. Matter (men have) thought was Reality. . . . (But) discoveries of the last fifty years (have) . . . demonstrated that matter is another form of energy. (Thus) physics has spoiled the nineteenth century picture of Reality."

An objective census of so-called psychic phenomena leads to the conclusion that these occurrences may not be passed off or ignored. In the face of a need for a redefinition of Reality and a place in the "scheme of things" for the psychic the author proposes to try "to find a scheme into which both psychic and physical phenomena might fit." He envisions "such a picture of the universe . . . (as) to inspire man with the idea that he is on the main line of cosmic events and not off on a side track as materially minded scientists have argued."

He considers that his problem involves two worlds—(1) his own inner consciousness or soul, and (2) everything else, or the "outer world." "Inner consciousness" communicates with the "outer world" by means of sensations. Sensations are physiological phenomena. How these physical phenomena become mental, i.e. knowledge, or produce a "mind picture" he considers a "quality gap" that philosophy has not adequately reckoned with. The heart of his "speculation" is his proposal to bridge that gap by the assumption of "a radiation of some kind . . . called A-rays . . . (as) a means of bridging the gap." This A-ray assumption together with six other postulates serve as a means, not only of interrelating the "soul" with the "outer world" but to make possible a place for psychic phenomena as a rational aspect of a sort of energy-centered Reality.

Physical scientists will not be surprised that he proposes that processes of aggregation are reversibly related to dispersions, in which energy is highly significant, as an over-all scheme of inanimate evolution. Similarly he sets up a pattern for the evolution of animate matter to its ultimate, most complex aggregate, man. By analogy he proposes a build-up of what he terms the "nimbus aggregate" or a non-material phase of the universe. It is in this phase that the religionist will find suggestions in step with his ideas of "things spiritual." In the first two of these series the chemist author gives an impressive brief of the parts that physics and chemistry take in the changes involved. Some of the more technical of these physical scientist readers may chafe a bit over the scant attention given to the relation of these reversible relationships to the second law of thermodynamics; evolution vs this law has been in the "scientific limelight" for some time.

In the final chapter our Senior-Scientist turns counselling-philosopher as he concludes, "the non-material phase of Reality . . . has a practical importance for the average man, deeply affecting his everyday life in a scope ranging from his safety to the price of butter. For this reason it deserves careful study from a strictly utilitarian standpoint." After pin-pointing, at least, four of these values of the non-material phase of Reality the suggestion is dropped." (There ought to be) another 'Rockefellar Foundation' . . . for research on the (non-material phase) and other phenomena of Reality."

This reviewer anticipates that the presentation followed in this book may have its greatest appeal to the physical scientists and the psychologists. Those who have read "Atoms, man and God" will find, in this, another approach to the problem which is basically the same.

B. CLIFFORD HENDRICKS

PLANE GEOMETRY, Revised Edition, by Rachel P. Keniston and Jean Tully, *Stockton Unified School District, Stockton, California.* Cloth. Pages vii+392. 18×25 cm. 1953. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.88.

This textbook is a revision of the first edition by the same authors. More algebraic applications have been added and the number of challenging exercises in the last half of the text has been increased. Coordinate geometry has been introduced, and methods of computing with approximate data are discussed. Two comprehensive sets of review exercises of the objective type have been added, and problem data and discussion materials have been brought up to date.

The objectives for teaching Geometry listed in the preface provide the teacher with a good background for the aims of the course. The introduction seeks to create a desire on the part of the student for the study of the subject by listing five reasons for such study.

A thorough groundwork in fundamental ideas, terms, definitions, assumptions, and theorems is given in the first three chapters. This section could be taught rapidly to groups that have had work in informal geometry.

The first two congruence theorems are postulated and that plan is used in other topics, such as in the first theorems on parallel lines and circles. Demonstrative proofs for some of the above appear in the appendix.

The coverage of topics is good and there is an ample number of exercises for the various units. Some applications to "shop" problems and other "practical" problems are included.

The great number of photographs and sketches help to foster an appreciation of the geometric aspects of our environment, and point out important applications in such fields as engineering, industry, and science. The abundance of such visual materials adds to the attractiveness of the text and should make it appealing to students.

The authors also include some materials relating the logic of geometry to reasoning in non-mathematical situations in order to make students conscious of the thinking processes.

Some concepts of solid geometry are introduced to stimulate the desire for further study of mathematics.

The discussion of computation with significant figures is in the appendix. Rules are given for determining when digits are significant, as are the rules for fundamental operations with approximate data. A lack common to most textbooks is that no work is given in geometric problems involving these principles.

Teachers will react according to their individual tastes to the length and breadth of the book and to the division of the pages into two columns.

The book as a whole is attractive, easily read, has a nice approach to geometry, and has so many applications to aviation, mil measures, and other topics that it can be classified as a good modern book for classroom use.

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THE ORIGIN OF LIFE, Second Edition, by A. I. Oparin, *Associate Director, Biochemical Institute, U.S.S.R. Academy of Science.* Translation with Annotations by Sergius Morgulis, *Professor of Biochemistry, University of Nebraska, College of Medicine, Omaha.* Paper. Pages xxv+270. 12.5×20.5 cm. 1953. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.70 Paper, $3.00, Cloth.

This book, now in its second edition, will offer very worth while reading for the biologist or chemist. The subject matter is exceptionally well organized, edited, and translated. The reader need not be a scientist of specific background to understand and enjoy the work. Three of the nine chapters are given over to the history of man's attempts to set up theories pertaining to life on earth. Then after a discussion of the primary forms of carbon and nitrogen compounds, Professor Oparin devotes three chapters to the probable origin of organic substances, colloidal systems, and finally, primary organisms. Most interesting to the biologist and bacteriologist will be the well-developed subject, "Evolution of Primary Organisms." All readers will appreciate the excellent summary of the last chapter—"Conclusion." It is good to have such a well-edited translation available to English-reading scientists and non-scientists. The translator is Dr. Morgulis of The University of Nebraska's College of Medicine.

JOSEPH P. MCMENAMIN

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## CHEMICAL PROGRESS WEEK

The important role of the chemical industry in American life will be brought home to thousands of Americans in their own communities by members of the Manufacturing Chemists' Association during the first annual Chemical Progress Week, May 17–22, William C. Foster, MCA president, announced today.

"Many of our member companies have done an excellent job in telling the story of the chemical industry on an individual basis," said Mr. Foster.

"Now for the first time our industry will band together to explain, all at the same time, the contributions to the American people that are resulting from the progress of the chemical industry in terms of individual welfare."

Charles S. Munson, MCA Board Chairman and Chairman of the Board of the Air Reduction Company, announced that the MCA Board will act as the national sponsoring committee for Chemical Progress Week.

On the basis that the best people to tell Americans about the chemical industry are their neighbors who work in it, most of the Chemical Progress Week programs will be carried out in the communities of the nearly 5,000 plants across the nation of MCA member companies.

Where two or more plants exist in a community, plant managements will be asked to form community committees. Representatives of many of the member companies have volunteered for special assignments for the industry observance and the work will be coordinated by the MCA Public Relations Department at 1625 Eye St., NW., Washington.

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Electrostatic air cleaner has been modified for suspension from the ceiling. Attached to the main return air duct of a forced-air heating system, the device screens 90% of all airborne dust, pollen and tobacco smoke particles from an average five- to seven-room house. It has no moving parts.

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New portable radio of a well-known make has been improved in its reception on all seven wave bands. The company reports that in a week of casual tuning, the radio picked up 43 foreign nations and almost every clear-channel broadcast station in the U.S.